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REPRODUCTIVE BEHAVIOR OF THE ALASKA FUR SEAL, *CALLORHINUS URSINUS*

BY GEORGE A. BARTHOLOMEW, JR. AND PAUL G. HOEL

The present study attempts, by means of direct observations, a mathematical model, and statistical analyses, to determine the time relations of various aspects of reproduction in the Alaska fur seal and to describe both quantitatively and qualitatively certain features of the social structure and breeding behavior of this species.

The Alaska fur seal has been more extensively studied than any other marine mammal. The general outlines of its life history have been familiar for many years; for example, see Osgood, Preble, and Parker (Bul. Bur. Fisheries, 34: 1–172, 1914). During fall, winter, and early spring the animals are strictly pelagic; the females and young scatter widely over the north Pacific Ocean; the adult males remain in the vicinity of the Bering Sea and the Aleutian Islands. In late spring the adult males (harem bulls) come ashore on the Pribilof Islands, establish territories spaced more or less evenly over the rookeries, and await the coming of the females (cows). The pregnant females and the young non-breeding males (bachelors) start coming ashore in the middle of June and continue to do so through July and early August. The cows are apportioned among the harem bulls. Most of the non-breeding males station themselves inland from the breeding animals. Within a few days after their arrival the females bear their pups and come into heat shortly thereafter. After mating they spend the rest of the summer feeding themselves at sea and nursing their pups on land. During the entire breeding season, which lasts approximately two months, the harem bulls stay in their territories without eating or drinking, but the subadult non-breeding males go to sea at irregular intervals. Toward the end of the breeding season, when the harems are disintegrating and the harem bulls are returning to sea, the virgin females come ashore, and at least some of them are fertilized by the young males which have not maintained harems.

Although during the last fifty years much time has been devoted to the study of the Alaska fur seal, detailed and quantitative data on the behavior of individual animals or specific groups of animals are not available. Because of the commercial importance of this species, most previous studies have been economic in purpose, and have, therefore, been concerned with the population as a whole.

The necessity of supplying practical answers to problems of management has precluded the possibility of prolonged detailed study of individuals or small groups. However, it is on such time consuming and often tedious observations that the solution of some of the intriguing problems presented by these unique and spectacular animals rests.

Methods.—The technique of study was the obvious one of careful and extended daily observations by the senior author of the undisturbed animals, and the detailed recording of their behavior at the time of observation. Although all of the rookeries on St. Paul Island were visited at one time or another, the quantitative study was confined to an isolated group of 20 harems in Kitovi Amphitheater which lies at the extreme north end of Kitovi Rookery. Between June 26, 1951, when systematic observations were begun, and August 6, 1951, when they were terminated, slightly over 220 hours were spent observing the harems in Kitovi Amphitheater. Partly to avoid disturbing the animals, but also to get out of the miserable weather which characterizes the Bering Sea, observations were made from a blind overlooking the study area.

In a study such as this, it is necessary to deal with known individuals. The limited areas occupied by the males, together with the variety of scars and wounds which they bore, made it possible to recognize many of them individually. However, the changes in location by the females and the pups and their lack of distinguishing individual characteristics made it impossible to follow any of them that were not marked or tagged. The cows and pups were marked either with small harpoon barbs to which were attached plastic strips, with flipper tags (Scheffer, Special Sci. Rpt. Wildlife No. 4, U. S. Fish and Wildlife Service, 1950) to which were attached plastic strips, or by daubs of quick-drying paint of the type used for marking roads. The last method proved to be by far the most satisfactory and convenient. The paint marks were applied with a cloth dauber attached to the end of a heavy bamboo pole. They gradually wore off, but some of the marked animals were still identifiable six to eight weeks after being marked. To avoid disturbing the social organization, no animals in the observation area were marked after July 2.

Either by individual characteristics or paint daubs it was possible to recognize all 20 of the harem bulls in the observation area, and on the basis of paint daubs and flipper tags it was possible to identify 40 cows and 20 pups. All the pups and females were marked in the same part of the rookery, and since they tended to remain in the general area where they were marked it was possible to keep a rather complete record of their activities.

In addition to following the marked animals, harem by harem censuses were made daily, tabular records were kept of the various types of behavior which were frequently repeated, and descriptions were recorded of all activities which appeared to be significant.

REPRODUCTIVE BEHAVIOR OF THE FEMALE

The reproductive activity of the female consists of two clear-cut but temporally overlapping spheres—parturition with associated activities, and impregnation. During the breeding season the males are continuously concerned with the females, but except for the

brief period of estrus, the females' reaction to the males is one of avoidance or indifference. Consequently one can consider those activities of the females which have to do with parturition and care of young separately from those concerned with impregnation.

While at sea the females are solitary or only slightly gregarious. Even at the height of migration at sea one ordinarily finds only isolated individuals, or at most a group of a half dozen, scattered over an area of a quarter or half square mile. Each summer they leave the water one by one and establish themselves individually in the rookery. In Kitovi Amphitheater in 1951, the peak of the pupping season was in the second week of July (Fig. 1),

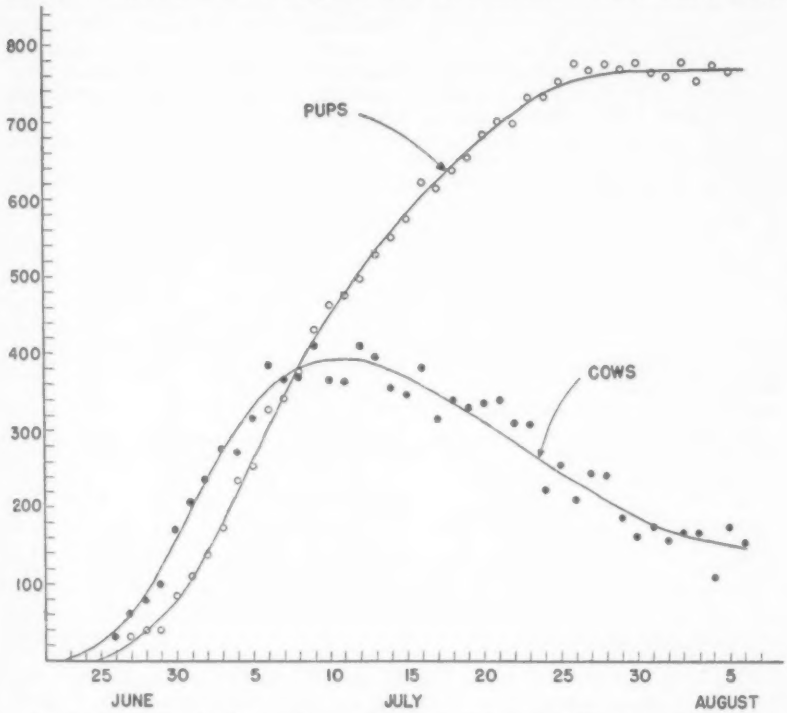

FIG. 1.—Daily counts of fur seal cows and pups in 20 harems in Kitovi Amphitheater.

but since the cows' arrivals were spread over a period of six weeks or more, females in various stages of their reproductive cycle were present on the rookeries at all times during the breeding season.

Interval between arrival and parturition.—For an observer to determine the interval between coming ashore and parturition is difficult, for it requires that a female be tagged or marked immediately upon arrival. However, two females were tagged just as they came ashore for the first time, and fortunately it was possible to observe parturition in one of these and to find the newborn young of the other only a few minutes after its birth. In the first instance, the time ashore prior to giving birth was three days, two hours, and 50 minutes; in the second, it was approximately one hour more than two days. Among scores of newborn pups observed, only one was born by a female still wet from the sea—she could not have been ashore more than two hours. Six untagged females, which could be followed

individually because they occupied isolated positions in the observation area, are known to have borne their young within one day of their arrival ashore.

As soon as they dry out after coming ashore, the cows are soft pearl gray; then, over a period of three to four days, they turn yellow-brown. No yellow-brown females with freshly born young were observed. This means that virtually all the pups are born within three days of the arrival ashore of the mother.

Interval between parturition and estrus.—Like most pinnipeds, the Alaska fur seal is characterized by a post-parturitional estrus, but the interval between parturition and estrus in this species has remained unknown. The marked females followed in the present study yielded some evidence on this point. To determine under field conditions the period between parturition and estrus, it is necessary to note when a female bears her young and when she is sexually receptive. Although 40 females were marked, it was possible to observe the copulations of only five that had pups of known age. The data for these five individuals, summarized in Table 1, indicates that estrus occurs four to seven days after parturition.

Estrus appears to last no more than a day, ordinarily. Most of the females copulate only once. In all instances in which marked individuals were involved, females went to sea either on the same day that they were served or on the day following. Although the

TABLE 1.—*Observed intervals between parturition and estrus*

TIME OF PARTURITION	TIME OF COPULATION	DAYS BETWEEN PARTURITION AND ESTRUS	
		Minimum	Maximum
Prior to morning of June 26	1:10 P.M. June 30	4¼	?
Morning of June 26	9:20 A.M. July 1	5	5
Between 4:00 P.M. June 28, and 9:00 A.M. June 29	4:00 P.M. July 3	4⅓	5
Prior to 2:00 P.M. June 30	4:27 P.M. July 5	5	?
Between 9:00 A.M. July 1, and 3:00 P.M. July 1	6:15 A.M. July 8	6⅔	7

peak of the females' receptivity appears to have passed when they leave to go to sea, some of them appear to be still mildly receptive and it is remotely possible that some of them mate again at sea. Although no signs of copulatory activity by swimming seals were observed, the Aleut natives report that they sometimes see seals going through copulatory motions at sea.

When a female is on her way to sea after having had coitus, she is often stopped by one of the males whose territory is at the water's edge. In virtually all such instances the female appears to be primarily interested in reaching the water. She does not solicit attention and attempts rather half-heartedly to avoid the male. If the male mounts her, however, a completed copulation often ensues. It is probable that not more than one in 40 of these departing females is served by a second male.

A second estrus never occurs. When returning from her trips to sea, the female actively avoids males. In the interval between parturition and the end of estrus, the vulva is swollen and protruding and the vestibular mucosa and vaginal orifice are a brilliant pink. By the time a female returns from her first trip to sea the swelling is completely gone and neither vestibular mucosa nor vaginal orifice are conspicuous. The entire vulva appears dark brown or black.

Mother-pup relations.—One of the specific goals of the present study was to work out in detail the nature of the mother-pup relations and to determine whether or not the cows nurse only their own young. It has long been assumed that the female fur seal nurses only

her own pup; and during the period of pelagic sealing up to 1911 this point was of great interest to the management. Nevertheless, actual proof had not previously been obtained.

The 40 marked females and 20 marked pups included 12 mother-pup pairs whose relationship we were able to establish in one of two ways: either the cow actively defended a newborn pup, or parturition was observed. Of the 12 pairs, only seven could be followed for more than a few days, because one member of each of the other pairs either lost its identification mark or died. During the seven weeks of observation at Kitovi, marked females and marked pups were seen nursing scores of times and except for two instances, in which two pups simultaneously but briefly nursed the same female, the females suckled only their own pups. All attempts by the pups to nurse females other than their mothers were vigorously rebuffed.

The most conspicuous feature of the suckling in this species is its periodic nature. A pup will lie at its mother's side nursing intermittently for a day or so and then the female will go to sea for several days to feed, leaving her pup ashore untended. Since a female

TABLE 2.—*Periods spent ashore and at sea by nursing females. Times are indicated to the nearest quarter of a day. For each female the sequence reads from left to right. The first column of figures indicates the duration of a female's first trip to sea following parturition; the second column, the duration of the stay ashore between first and second sea trips, etc.*

FEMALE	AT SEA	ASHORE	AT SEA	ASHORE	AT SEA	ASHORE	AT SEA
B	6¾	3	9¼	3	10¾	—	—
C	6¾	2¼	—	—	—	—	—
D	4¾	3¼	8¾	1	—	—	—
E	5	1¾	8¼	2	10	1	—
F	3¾	1¼	5¾	1	7¼	1¾	10
H	7½	1	9	3	—	—	—
M	7¾	1	8¾	2	—	—	—
N	8¾	1¼	10	1	—	—	—
O	4¾	1	—	—	—	—	—
P	5¾	1	5	1¼	6¾	1¼	—
Q	5	1	7	1¾	7	1	8
R	4½	1¼	7¼	1¾	6½	1	—
Mean	6	1½	7¾	1¾	8	1¼	9

will nurse no pup but her own, a pup necessarily goes without food while its mother is at sea. The length of the female's stay at sea and the percentage of the female population which is at sea at any one time has been little studied.

A careful record was kept of the presence or absence of the marked females. Frequent searches were made of the observation area with binoculars and telescope, and arrivals and departures of marked females were noted. In this manner the intervals at sea and the periods on land of the marked females were determined (Table 2). The stays ashore were shorter and the stays at sea were considerably longer than was anticipated on the basis of the estimates of previous workers. Sojourns at sea of as long as eight or ten days were frequent, while the usual stay ashore was two days or less. This means that for periods of a week or more the young go without feeding and that on the average they are attended by their mothers for not more than one day in four or five. The first trip to sea appears to be shorter than the others. The stimulus causing the females to return from sea is completely unknown, but it is possible that they return when their mammary glands are full. If so, either a diminution in the rate of milk secretion or an increase in the pup's demands could cause females to stay at sea longer as the season progresses.

A STATISTICAL MODEL FOR ESTIMATING THE TIME RELATIONS OF THE VARIOUS BREEDING ACTIVITIES

In the preceding description of the behavior of female fur seals, estimates are given for such biological parameters as the time between arrival ashore and parturition, the time between parturition and estrus, and the time between nursings. These estimates are based largely on data obtained from marked animals. Since the number of marked animals available was small, the estimates cannot be considered to be very accurate unless substantiated by other evidence. Such evidence can be obtained by introducing a statistical model for the essential activities of the female, determining this model with considerable precision by using the extensive data available on the daily sizes of the cow and pup populations, and then obtaining accurate estimates of the desired parameters from this model.

In the summer of 1951, the females began to arrive about the middle of June and when observations were begun June 26, there were 31 females in Kitovi Amphitheater. During the observation period, harem-by-harem censuses were made every morning. The growth and decline of the population of females during the breeding season is shown in Figure 1. The trend of the population, as indicated by the freehand curve fitted to the data, was strongly upward until the end of the first week in July when it leveled off. By the end of the second week in July it began to decline, and it continued to fall off during the rest of the observation period. This curve, however, does not indicate the timing of the arrival of the females on the rookery; rather it expresses the equilibrium between the numbers of incoming and outgoing females.

The number of pups in Kitovi Amphitheater increased daily until July 26, and pregnant females could occasionally be seen coming ashore until the end of the observation period. However, when the pup population was near its maximum, counting errors were so large that no further increase in the size of the population of pups could be discerned after July 26. The growth of the pup population during the breeding season, and its freehand-fitted trend, are also shown in Figure 1.

The model that is about to be introduced assumes that each day of the breeding season has a certain probability that it will be the day of arrival for a randomly selected female and that the females inhabiting Kitovi Amphitheater can be considered as a random sample of all the females with respect to the time of arrival. Then, for a given population size of females, there will exist expected frequencies of females arriving for each day of the breeding season. The following notation will be needed for the model. Let

- N = total number of females observed
- f_i = number of females expected to arrive on the i*th* day
- F_i = number of females expected to be in residence on the i*th* day
- α = mean number of days that females are in residence before first going to sea
- β = mean number of days that females are away on first trip to sea
- γ = mean number of days that females are away on their second and subsequent trips to sea

Since observations on marked animals indicate that females spend approximately two, or possibly fewer, days ashore when returning to nurse their young, it will be assumed in the model that the mean number of days ashore on such visits is two. Using this assumption, the proposed model expresses F_i in terms of the f_i by means of the following formula:

$$F_i = f_i + f_{i-1} + \cdots + f_{i-\alpha+1} + f_{i-\alpha-\beta} + f_{i-\alpha-\beta-1} + f_{i-\alpha-\beta-\gamma-2} + f_{i-\alpha-\beta-\gamma-3} + f_{i-\alpha-\beta-2\gamma-4} + f_{i-\alpha-\beta-2\gamma-5} + \cdots \quad (1)$$

This formula arises from counting all females that arrived on the i*th* day or on one of the $\alpha - 1$ preceding days; counting those who came $\alpha + \beta$ and $\alpha + \beta + 1$ days earlier because they will have been in residence α days, have gone to sea for β days, and have returned to nurse their young on the $i - 1$*th* or i*th* day; counting those who came $\alpha + \beta + \gamma + 2$ and $\alpha + \beta + \gamma + 3$ days earlier because they will have gone though the cycle of the preceding group and will also have been gone γ days on the second trip; etc.

Since (1) is assumed to hold only for the expected frequencies, it is necessary to find good approximations to these frequencies if (1) is to be tested for its validity. The total sample of females is large; hence a smooth curve fitted to the observed F_i given in Table 3 should give a good approximation to the expected F_i. The curve in Figure 1 for the female population may therefore be considered as yielding the expected F_i to a good approximation. Good approximations to the expected f_i can be obtained by using the relationship between female arrivals and pup births. Since each female gives birth to a single pup approximately two days after arrival, the theoretical frequency distribution of female arrivals, given by the f_i, should be about the same as the theoretical frequency distribution of pup births, except for a shift of about two days in the time scale. But a good approximation to the theoretical frequency distribution of pup births can be obtained by fitting a smooth curve to the pup data given in Table 1. The curve in Figure 1 for the pup popula-

TABLE 3.—*Daily counts of cows and pups in 20 harems in Kitovi Amphitheater, summer of 1951*

DATE	NUMBER OF COWS	NUMBER OF PUPS	DATE	NUMBER OF COWS	NUMBER OF PUPS
June 26	31	?	July 16	378	625
27	63	30	17	317	616
28	80	55	18	340	640
29	98	58	19	332	657
30	171	86	20	337	686
July 1	204	114	21	340	705
2	236	141	22	312	702
3	272	172	23	309	738
4	270	235	24	222	738
5	318	256	25	256	756
6	388	328	26	212	780
7	367	345	27	244	769
8	369	375	28	242	778
9	409	433	29	186	769
10	366	463	30	163	781
11	361	476	31	177	765
12	410	499	Aug. 1	158	762
13	396	527	2	167	782
14	358	548	3	166	758
15	345	576	4	107	777
			5	173	769

tion may therefore be considered as yielding the theoretical f_i for pup births to a good approximation. Since $f_i = F_i - F_{i-1}$ is valid for pup frequencies, although it is not valid for female frequencies, this technique will yield a good approximation to the f_i for females, provided the proper shift of about two days in the time scale is made.

The validity of the model given by (1) together with the correctness of whatever values are chosen for α, β, and γ may now be appraised by observing whether formula (1), when applied to the f_i obtained from the pup curve, yields values of the F_i that agree with those given by the F_i curve in Figure 1, after the latter curve has been shifted a suitable amount. Assuming that the model is correct, the values of the parameters α, β, and γ which give the best correspondence between these two F_i curves may be considered to be the best estimates of those parameters. Since all the parameters are taken to be integers, the best estimates can be found by trial and error methods.

Application of the foregoing methods showed that the best estimates for the parameters are $\alpha = 10$, $\beta = 5$, and $\gamma = 8$. The F_i curve of Figure 1 and the F_i curve given by formula

(1) with these parameter values, after a shift of two units to the left in the latter, are shown in Figure 2. The excellence of the agreement indicates that the model is realistic and that the estimates of the parameters are good. Changing α by a unit will alter the curve considerably; hence $\alpha = 10$ may be considered as an accurate estimate of the value of α. Changing either β or γ a unit will alter the curve somewhat but not to the same extent as altering α, hence the estimates $\beta = 5$ and $\gamma = 8$ cannot be considered as reliable as the estimate for α. Since it was necessary to shift the F_1 curve obtained from the pup data two units to the left in order to obtain a fit with the F_1 curve for females, it is established that the mean time between arrival and parturition is two days. Any change in this shift will clearly give a poor fit; hence this estimate may be considered to be accurate.

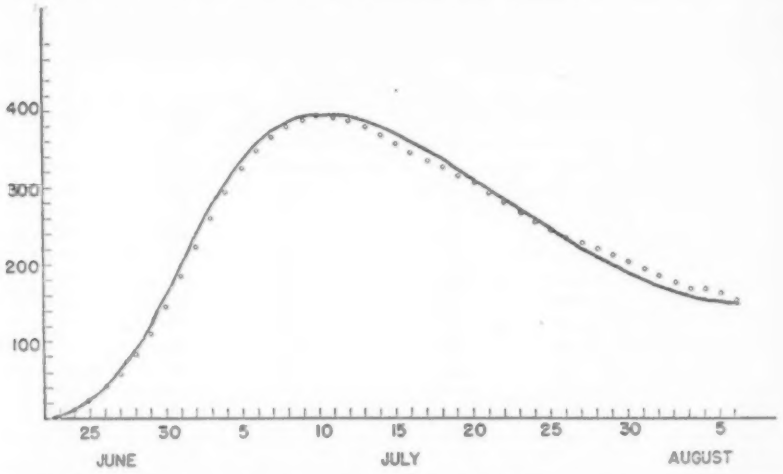

FIG. 2.—Population of fur seal cows in 20 harems in Kitovi Amphitheater. The solid line represents the smoothed daily counts. The circles denote population size as calculated from the mathematical model.

A comparison of the estimates obtained from marked animals and from the preceding technique shows that the two sets of estimates are in good agreement. For marked animals, the time between arrival and parturition ranged from less than one day to more than three days. The model estimate is two days. For marked animals, the time between arrival ashore and first departure ranged from about eight days to 11 days. The model estimate is $\alpha = 10$ days. For marked animals, the mean times at sea on the first and second trips were about six days and eight days, respectively. The model estimates are $\beta = 5$ days and $\gamma = 8$ days. From data on marked animals, it was observed that the time between parturition and estrus ranged from five to seven days. If it is assumed, as observations indicate, that the female goes to sea one day after estrus, the estimate from the model for this time interval is seven days. Further evidence substantiating the accuracy of this estimate will be presented in a later section. This agreement between the estimates of the various parameters adds further validity to the reasonableness of the model and to the accuracy of the estimates obtained by its use.

Variability of data.—The preceding methods were based on the assumption that the observed values of the f_i could be treated as the frequencies that one would obtain in taking random samples of females. If one compares the observed and expected values of the f_i he will find that the variability is greater than it should be for random sampling. Since,

when the populations became large, there was a considerable error in counting females, and particularly pups, it may be that the excess variability can be attributed mostly to the counting error. Now it is really only necessary to assume that the smooth curves in Figure 1 may be treated as giving good approximations to the F_i in order to justify the methods that have been used; hence the justification will follow if it can be shown that the observed f_i behave like random sample frequencies plus independent counting errors of the size known to occur.

Since the pup population stopped growing about ten days before the end of the observation period, the variation in the last 11 sample values of the F_i for the pup population may be considered as due to the counting error only. The variance of these errors will be found to be 68. Now if one assumes that the variance of the error of counting over the entire period of observation is proportional to the size of the population being counted, it is possible to estimate the variance of the errors by another method using all the data, and thus see whether or not the explanation of the excess variability in terms of counting error is a reasonable one. By introducing the chi-square goodness of fit function, it can be shown that the constant of proportionality just assumed can be estimated accurately by the formula

$$k = \frac{\sum_{i=1}^{c} (o_i - f_i)^2/f_i - (c - 4)}{2 \sum_{i=1}^{c} F_i/f_i - c},$$

where c is the number of observation days, o_i is the observed number of pups born on the *ith* day, and f_i and F_i refer to the theoretical frequencies for the pup population. If this formula is applied to the pup data of Table 3, it will be found that $k = .11$. Since it was assumed that $\sigma_{c_i}^2 = kF_i$, it follows that σ_o^2 for the last ten days of observation should be approximately that given by replacing F_i by its Figure 1 value near the end of the curve. Choosing $F_i = 772$, it then follows that σ_o^2 for the last ten days should be approximately equal to 85. A significance test will show that the sample variance of 68 is compatible with the theoretical value of 85; hence it follows that the error assumption is a reasonable explanation of the excess variability and therefore that one need not question the assumption of randomness because of the excess variability.

If an attempt is made to follow high and low frequencies for the female population and correlate them with those for the shifted pup population, it will be found that the method fails. This failure is due in part to the conspicuous short-term fluctuations in the number of females ashore that are caused by daily variations in weather. Rain and spray disturb the females which are ashore. A heavy rain will cause many of them to desert the rookery and go to sea for a number of hours. It also causes to stay at sea females who otherwise would come ashore. Similarly, a heavy windstorm that sweeps the seaward harems with spray and spume will cause a temporary diminution in the number of females in these harems. On a calm rainless day following a period of storm, the rookeries have an unusually large female population. To smooth out the effects of such disturbances, an averaging process such as that used in Figure 1 is needed.

REPRODUCTIVE BEHAVIOR OF THE MALE

No mammal behaves in a more spectacular manner during its breeding season than the bull Alaska fur seal. He goes without food or water for two months or more. He defends a territory by aggressive behavior so fierce that not infrequently mortal wounds result, and at the same time he maintains a harem which may contain as many as 100 cows. Nevertheless, no detailed study has ever been made of this remarkable performance. No specific data on such things as duration of harem maintenance, integrity of harems, and relation of harem size to reproductive performance are available in the literature. The present study attempts to supply such documentation.

Harem maintenance.—A census of the seals in each of the harems in the study area was taken daily between 8:00 and 11:00 A.M. The histories of four typical and adjacent harems are summarized in Figure 3.

Most of the males establish their territories before the females arrive (Pl. I). The females come ashore and join a harem by settling down wherever room is available. Consequently, males that have territories close to the water acquire harems earliest. Males near the water may obtain their full complement of females before the males farther inland acquire any females at all. There are two reasons for this. The most important factor is the gregariousness of the females. As long as space is available, females coming ashore join harems that are already established; the choice of a harem by the female appears to be made without reference to the male. Indeed, for the fur seal cow, mate selection as such does not exist

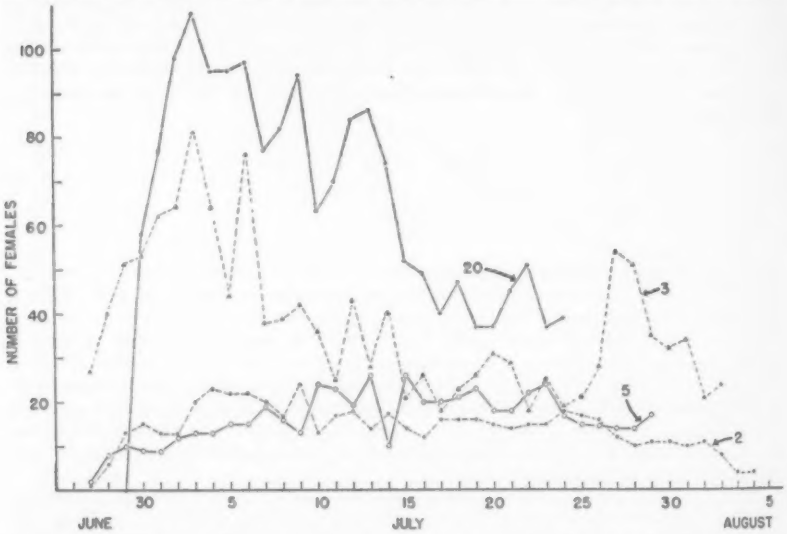

FIG. 3.—Histories of four typical and adjacent harems in Kitovi Amphitheater. The territories of male number 2 and male number 5 were largely bounded by ledges or crevices while the territories of male number 20 and male number 3 were not delimited by topographic features (see Fig. 4).

The second and less important factor is the extremely zealous harem maintenance by bulls. If a cow attempts to leave his harem, the bull will chase her and drive her back or seize her in his mouth and throw her back. But even so, a bull is never able to keep a cow in his harem for more than a few minutes if she is determined to leave.

A territory-maintaining male that has no females will frequently dash to the edge of a harem adjacent to his territory and seize with his teeth a female by whatever part of her body happens to be nearest, carry her into his territory, and drop her. Within a few minutes, while the male is occupied with territory defense, or is lying down to rest, the female usually scurries back to the harem from which she was stolen. As a result, raiding is usually futile unless the male can accumulate four or five females. The females are so gregarious that a smaller group is unstable, at least in the early part of the breeding season. Consequently, a male must make many raids before he can establish even a small harem.

The size of a male's harem is more dependent on the location and topography of his territory than upon his diligence and vigor. Large harems develop first in territories which

PLATE I

UPPER. A view of part of the study area in Kitovi Amphitheater on June 26, 1951. The bulls are on their territories and the cows have begun to aggregate in harems near the edge of the water.

LOWER. Same view, July 5, 1951. The number of cows has increased greatly and nearly all the bulls now have harems.

occupy relatively flat areas, which are topographically delimited in such a manner that the male need defend only a part of the perimeter, and which are conveniently accessible to the water but not immediately adjacent to it. If a territory abuts on the water, it is continuously disturbed by the attempts of nonterritorial males to hold females in the shallow water at the edge of the shore or to establish themselves on land.

In just a few days, early in the breeding season, a male occupying such a favorably located territory may acquire a hundred or more females, so many that they literally overflow his territory and spread into the areas of adjacent harem-less males which immediately preempt them. The new harems thus established then begin to grow at the expense of the big one. Thus, in some circumstances, harems grow rapidly and fluctuate widely in size from day to day (note harems 3 and 20 in Fig. 3).

TABLE 4.—*Daily total copulation rate of 20 harem bulls in Kitovi Amphitheater*

DATE	COPULATIONS PER HOUR	DATE	COPULATIONS PER HOUR
June 26	.00	July 16	1.71
27	.29	17	1.57
28	.13	18	1.00
29	.40	19	1.20
30	.66	20	1.29
July 1	.53	21	1.67
2	.33	22	1.43
3	1.00	23	1.42
4	2.00	24	.86
5	1.07	25	1.00
6	1.71	26	.71
7	1.50	27	.29
8	1.86	28	.57
9	2.00	29	.86
10	1.29	30	.86
11	2.00	31	.33
12	1.54	Aug. 1	.33
13	2.86	2	.50
14	3.71	3	.00
15	1.00	4	.00
		5	.00

On the other hand, if a male's territory is small and occupies an area delimited by rocks or cliffs in which there is room for only a limited number of females, the size of the harem may remain relatively constant throughout the breeding season (note harems 2 and 5, Fig. 3). In all cases, however, because of the arrivals and departures of pregnant and postestrous females, the composition of a harem changes from day to day. When a pregnant female comes ashore, she may establish herself in the first harem she reaches or she may wander through several harems before settling down to bear her pup. If she happens to occupy a position that is near the boundary between two harems, she may be fertilized by the male of either territory. When she comes ashore after her periodic trips to sea she usually returns to the same section of the rookery in which she bore her pup, but she makes no effort to rejoin her previous harem. Instead, she settles down wherever she happens to find her pup.

Mean harem size.—Although it has long been known that polygyny is more strongly developed in the Alaska fur seal than in any other mammal, precise quantitative data have not previously been available. The ratio of breeding females to harem bulls in Kitovi Amphitheater during the breeding season of 1951 was 39:1. The estimated total number of

cows which belonged to each of 19 harems is shown in Table 5. The mean number of females per harem was only 16, for during most of the summer fewer than half the breeding females were ashore at any one time.

Duration of harem maintenance.—Vigorous harem maintenance by bulls begins as soon as the first cows come ashore in June. During the 1951 breeding season in the study area this harem maintenance began to decline almost imperceptibly about July 21. By July 25, a general loosening of the social organization was conspicuous, and by August 2, no distinct harems remained. The period of harem maintenance in the 20 stable harems varied between 18 and 41 days with a mean of 31 days. There was no way of telling whether or not the time of a harem bull's departure from the rookery was correlated with the time of his arrival on the rookery, because most of the harem bulls had already established their territories when observations were begun. Although such imponderables as vigor and stamina are often of critical importance, other things being equal, a male with a territory in terrain

TABLE 5.—*The relation between number of copulations and size of harem. The methods for determining harem size and copulation number are described in the text. The males are ranked in order of decreasing harem size*

MALE NO.	NO. OF COPULATIONS	NO. OF FEMALES	RATIO: COPULATIONS TO FEMALES
20	142	153	.93
3	87	108	.80
1A	161	82	1.97
11	75	55	1.36
16	55	45	1.22
5	78	43	1.81
2	38	35	1.08
13	122	34	3.59
15	38	32	1.19
22	7	28	.25
11A	21	26	.81
6	38	22	1.72
10	0	19	.00
14	34	17	2.00
1	0	16	.00
1B	68	13	5.23
4	37	13	2.84
7	17	11	1.55
8	0	3	.00

that is easy to defend tends to hold his harem longer than a male with a territory that is difficult to defend. Most of the arriving and departing females moved through territory 1B, for it occupied the only stretch of shore which afforded convenient access to the harems in the study area (Fig. 4). For this reason also, most of the males that tried to move into the rookery from the sea attempted to establish themselves in territory 1B. As a result, throughout the breeding season this territory was a center of confusion and fighting. Territory 1B was occupied by a succession of males, none of which was able to withstand the attrition for more than 18 days and most of which could maintain themselves for only a few days. The resident male was continuously under stress. He was incessantly busy, either fighting off males that wanted to establish themselves, or attempting to incorporate departing or arriving females into his harem.

Males number 6 and number 7, both of which were still in residence, but not holding females or defending territories when the study ended, maintained their harems for at least 41 days. The reason for their long period of harem maintenance and residence seemed

to be the isolated position and readily defended location of the areas which they held. The integrity of their harems was for the most part assured by the nature of the terrain. Although the two males maintained adjacent territories, there was little conflict between them because the boundary between their territories was determined by a rock ledge. The

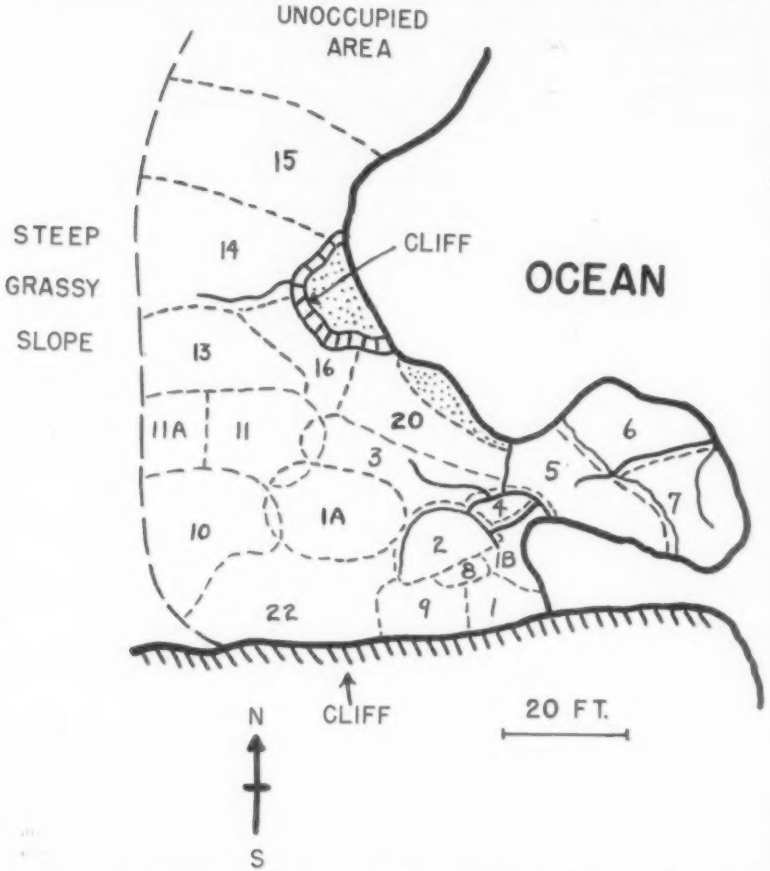

FIG. 4.—Distribution of territories in the study area in Kitovi Amphitheater, summer of 1951. Broken lines represent territory boundaries. Thin solid lines represent ledges or crevices. The nature of the terrain is shown in Plate I. Stippled areas, although occupied by seals, were not included in the study because they were not clearly visible from the blind.

two territories were situated on the edge of a low cliff and were practically inaccessible from the sea. Ordinarily, no more than a vocal threat was needed to cause the withdrawal of males awkwardly attempting to scale the low cliff on the seaward perimeters of these territories. The two territories could be approached from the main rookery area only through the area occupied by male number 5, whose territory maintenance thus protected the landward sides of the two areas.

Although one might expect that a large harem would not be maintained for as long as a small one, such is not the case. For example, male number 3, an animal in his prime, held a very large territory and maintained a harem with a mean population of 38 cows for 38 days. In contrast male number 8, an old and decrepit animal with three canines missing, managed by bluffs and threats to hold a territory of about 60 square feet—little more than enough room in which to turn around. The mean size of his harem was two and the period of his harem maintenance was only 20 days.

Departure from the rookery.—During the first half of the breeding season the attachment of the bull fur seal to his territory is extremely strong. In most cases it is literally impossible for a man or a rival seal to drive him off his territory; even a potential threat to his territory by another bull will evoke a violent aggressive reaction. As the end of the breeding season approaches, the degree of aggressiveness and the strength of the territorial attachment decline markedly; bulls sometimes abandon their territories spontaneously, and often a very slight disturbance by another seal will cause a bull to leave the area he has defended so zealously and return to the sea. Sometimes a bull that stays in his territory after he has ceased any but the most perfunctory harem maintenance will watch with apparent unconcern while a subadult male wanders through the area which a week before he defended furiously against all intruders.

Harem maintenance and territory occupancy stop long before the females and the pups leave the rookery. Consequently, no organization is apparent on the rookeries during the late summer and early fall.

Sexual activity.—The elaborate pattern of activity involved in harem maintenance and territorial defense is significant only in so far as it allows a male to fertilize females. Therefore, from the evolutionary standpoint it is important to ascertain whether or not a male's reproductive success is correlated with his success in harem maintenance. The best available measure of a male's reproductive success is number of copulations. A tabular record was kept of the time of occurrence, and when possible the duration, of every copulation which took place in the study area during the period of observation. To furnish a basis for the interpretation of these numerical data, detailed descriptive records were kept of all the aspects of male behavior which were immediately sexual.

Most of the activities of harem maintenance are directed toward pregnant, pre-estrous, or post-estrous females, but male fur seals show direct sexual interest only in those females which are in heat. Although it is often possible for an observer to determine whether or not a female seal is in heat on the basis of her behavioral and postural mannerisms, the male seal appears to identify the estrous female almost exclusively by smell. One of the most frequent and characteristic performances of the harem male is his search for estrous females. A male will rouse himself, then move vigorously and rapidly about his harem, often completely circling it, sometimes tacking back and forth through it, sniffing energetically at the noses of his females. If one of the females smells as if she is in estrus or approaching estrus, the male then smells her vulva. When the female is in or near heat, she characteristically coöperates by arching her back and making her perineum more accessible. If the female is in estrus copulation ensues promptly, with the male playing the active role throughout. Quite frequently the male does not even bother to smell the female's vulva, but moves into copulatory position immediately after obtaining the appropriate olfactory clue from the female's nose.

By means of these periodic excursions through and around his harem, the male serves his females one after the other as they come into heat. Once the breeding season is well underway, the male operates methodically and relatively calmly, but early in the season as the first few of his females come into heat, he behaves in a very excited manner. He may copulate several times with the first of his estrous females, but with subsequent females a single copulation is the rule. Although there is a decline in a male's sexual interest as the breeding progresses, during most of the breeding period his reproductive capacity usually appears to be adequate even when several of his females come into heat on the same day. Even while copulating with one female, a male may show sexual interest in another female

by sniffing energetically at her nose. Males frequently copulate with two females within a half hour, and once a male copulated with two females within 16 minutes. For a male to copulate four or five times in as many hours is not unusual, and in one instance a male which had been mating regularly for a number of days copulated with six different females in five hours and 17 minutes.

Changes in sexual behavior during the breeding season.—The duration of intromission was recorded whenever it could be determined. Toward the end of observations, when the breeding males were abandoning their harems, the copulations were slightly more prolonged than during the early and middle parts of the breeding season. Thus, if the 132 copulations which were timed are divided into three equal chronologically arranged groups, the mean duration of copulation for these groups will be found to be 5.9, 5.7 and 7.1 minutes, respectively. However, the change in the behavior of the males toward the estrous females as the end of the period of harem maintenance approached was more conspicuous than the increase in duration of coitus. It was repeatedly noted that a day or so prior to departing from the rookery, males became conspicuously dilatory in their sexual activities even though they continued to serve their females. Whereas early in the season males immediately mounted estrous females and completed copulation without interruption, on the last few days of their stay ashore the males frequently behaved in a manner that suggested sexual fatigue or at least a decline in interest. Before actually beginning coitus, they often mounted and dismounted a given female several times over a period of half an hour before completing copulation. There is no reason, however, to believe that these dilatory copulations were less effective in fertilizing the females than the more expeditious copulations earlier in the breeding season. Males which were collected early in August, 1951 (this is at the end of the organized breeding season) by Karl W. Kenyon and Ford Wilke, and examined histologically by Dr. Richard J. Blandau, had fully active testes.

Efficiency of harem bulls.—In order to estimate by means of available data the reproductive efficiency of the harem bulls, it is necessary to assume that the copulation rate of males may be used as a measure of their fertilizing efficiency. A high level of sexual vigor does not necessarily indicate a high level of fertility; nor does low sexual vigor indicate low fertility, but other things being equal, it is reasonable to assume that those males which copulate with the most females fertilize the most females.

Table 4 gives the observed copulation rate per hour for the 41 days of observation. Since the day-to-day variation is extremely large, a smooth curve was fitted to these rates after they had been multiplied by 24. The resulting curve, which is shown in Figure 5, may be considered to be an estimate of the frequency distribution of copulations for the population under consideration. These estimates may be too large because the copulation rate for day time observations may not hold for all 24 hours of the day. However, no diurnal variation in the level of activity of the rookeries is apparent. Kitovi Amphitheater was visited at all times when there was enough light for observation (2:00 A.M., to 11:00 P.M.) and no significant differences in behavior associated with time of day were noted. If noise is a criterion, there is little diminution in male activity even during the brief hours of subarctic darkness.

Figure 5 also shows a curve that represents the estimated daily number of estrous females. This curve was obtained in the following manner. Differences between successive daily counts of pups were taken from the pup curve in Figure 1 to give estimates for the daily number of pup births. These estimates were graphed and smoothed to give a more refined estimate for the expected daily number of births. The resulting curve was translated two days to the left and treated as a refined estimate for the expected number of daily arrivals of new females. The validity of using the pup census for estimating the frequency distribution of female arrivals lies in the fact that each newly arrived female produces one pup and the fact that the mean time lag between arrival and parturition is two days. The curve for female arrivals obtained in this manner has been centered so that its maximum agrees with the maximum for the copulation curve. The justification for making the maxima agree is that the maximum number of copulations should occur when

the maximum number of females are in heat and this latter date should occur a fixed number of days after the date when the maximum number of females arrived. If, for example, the copulation maximum occurred to the right of the translated maximum for female arrivals it would imply that at first the copulation rate decreased steadily, then increased for several days, and then decreased steadily again, which is unlikely.

With this centering it will be found that the difference in the time scales for the two curves is nine days. This is precisely the estimate obtained from the statistical model (1) for the time between arrival and estrus. The excellent agreement here with the statistical model based on daily censuses adds further validity to the conclusions previously made and also to the conclusions about to be made.

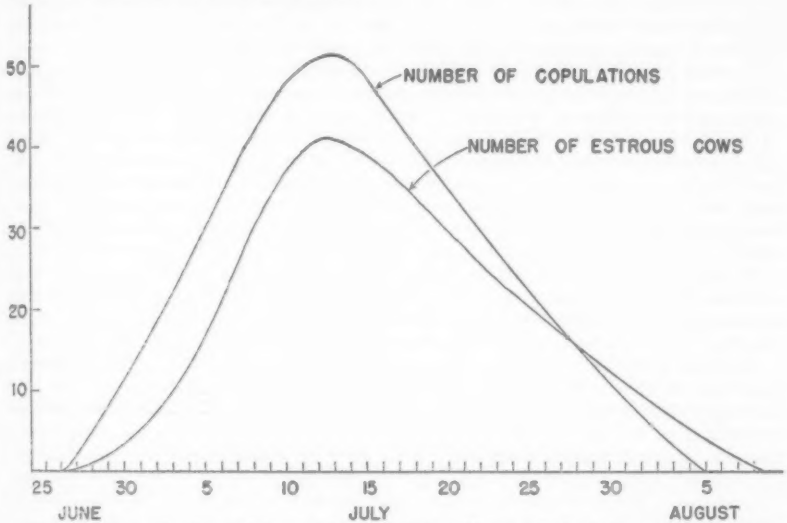

FIG. 5.—Reproductive efficiency of harem bulls. The method of determining the two curves is described in the text.

A comparison of the two curves of Figure 5, shows that the males are giving adequate service during the early and middle parts of the season, i.e., on the average slightly more than one copulation per estrous female, but that they are not doing so near the end of the season, i.e., not all the estrous females are being served. Since the copulation curve was based on the assumption that the copulation rate obtained from day time observations holds during the entire 24-hour period, and since the true rate may be somewhat lower, and since as pointed out earlier the female curve may be slightly higher than indicated in Figure 5, it follows that the deficiency of copulations near the end of the season may be more pronounced than Figure 5 indicates, and that this deficiency may extend considerably further back in time.

Figure 5 demonstrates that only during the first week of the breeding season was the average number of copulations per female as high as two. Thereafter the rate decreased rather rapidly, showing that for most of the females there was but one copulation. The copulation curve in Figure 5 was based on a total of 220 hours of observation. Since these hours of observation constitute approximately 20 per cent of the organized breeding season, the copulation curve is quite reliable, provided the assumption that the copulation rate is independent of the hour of the day is valid. The average number of copulations per female for the entire breeding season based on this same assumption is 1.3.

If the copulation rates for the various males are treated in the same manner as the total copulation rates were treated in the preceding paragraphs, the estimates given in Table 5 for the total number of copulations for each male will be obtained, based once more upon the assumption that the observed rate holds for the entire 24-hour period.

If it is assumed that the number of females belonging to a harem, and hence requiring service, is proportional to the sum of the daily observed number of females in the harem, then an estimate of the total number of females belonging to a given harem can be obtained. It is merely necessary to calculate the ratio of the daily census of a given harem to the daily census of all the harems, and then take this ratio of the known total number of breeding females. The total number of breeding females should be about the same as the total number of pups born, alive or dead. For Kitovi Amphitheater this total was estimated to be 780; hence the foregoing ratios were taken of 780. The resulting estimates for the number of females belonging to each harem are listed in Table 5.

An inspection of the fourth row of Table 5, which gives the ratio of copulations by the various males to the number of females in their harems, shows that the variability in estimated male activity is very large. If the 19 males are ordered with respect to the size of their harems and then are divided into three groups consisting of the first six, the second six, and the last seven, it will be found that the ratios for these three groups are 1.23, 1.49, and 1.70, thus showing a slight trend in the direction of increased efficiency of fertilization with decreased harem size. If the two largest harems are deleted, this trend will disappear; hence about all that can be said here is that males do not appear capable of servicing a harem of more than 100 females.

If the males are arranged in order of their Table 5 ratio values and the number of days of harem maintenance is treated as a correlated variable, it will be found that there is no relationship indicated for these two variables. A similar conclusion can be made for the variables harem size and onset of harem maintenance.

Although individual variations, both physiological and psychological, are undoubtedly important in determining a male's reproductive effectiveness, such factors do not lend themselves to analysis under field conditions. However, some of the apparent irregularities in Table 5 are related to a factor which is readily studied and which has proved to be important in many aspects of the social behavior of fur seals, namely territory location. For example, males number 1B and number 4, whose territories lay on the principal route of departure of the females from the study area, served many more females than would be expected on the basis of harem size. The high copulation rates of these two males are caused by the fact that they occasionally had coitus with females from more inland parts of the rookery when these females were on their way toward the water on the first of their periodic trips to sea.

Efficiency of the fur seal social organization.—From the standpoint of reproduction, the social organization of the Alaska fur seal appears superficially to be inefficient. The sex ratio presumably is equal yet in a given year only one male in approximately 40 regularly serves the females. Although the copulation rate of this minority of bulls is adequate to take care of all the females coming into estrus during the early and middle parts of the breeding season, toward the end of the organized breeding period these males appear to be unable to serve all their females. Some of the females must, therefore, depend for fertilization on the subadult males that intercept them when they make their first trip to sea.

No matter how inefficient, wasteful, or imperfect the breeding organization may appear to be, however, if it enables the population to maintain itself, it must be considered adequate. That the present social setup is adequate is suggested by the steady growth of the fur seal population over the past 30 years. The population now appears to have become stable and any further increase does not appear imminent as long as the present system of management is maintained (Kenyon, Scheffer, and Chapman, ms.). It therefore becomes of interest to determine whether or not the maximum biotic potential of the species is currently being realized and this is merely to ask the question, "Is the maximum possible number of females being fertilized?"

The most satisfactory data for frequency of conception of female fur seals have been gathered by Wilke (Prelim. Study No. 67, Gen'l. Hdqtrs. Supreme Comm. Allied Powers, 1951) who found that of 191 females four years old or older which were collected in March, April, and May of 1950 off the coast of Japan, 83 per cent were pregnant. It is not known how many of the non-pregnant 17 per cent failed to conceive because of inadequate service by the males, and how many were sterile or had aborted. From this group of 191 females, however, of the 96 females six to ten years old—presumably at the height of their reproductive capacity—92 per cent were pregnant. This suggests that virtually all the females are served. Thus, it cannot be said that the social organization of the fur seal is reproductively inefficient despite the very large number of non-breeding males. Nor does it appear that the present rate of exploitation of the non-breeding males for commercial purposes is excessive. Apparently the present policies of management allow a sufficient escapement of three- and four-year-old males so that the fertilization of females, at least in the six to ten year age classes, is virtually maximal. Pearson and Enders (1951, Anat. Rec., 111: 695–712) present figures for reproductive failure in another population of fur seals collected in 1949 which are in agreement with this thesis.

ACKNOWLEDGEMENTS

This work was carried out in collaboration with the United States Fish and Wildlife Service and was undertaken at the suggestion of Dr. Victor B. Scheffer, whose arrangements and help were of invaluable aid. Mr. Clarence L. Olson and Mr. Charles H. Anderson made available the facilities of St. Paul Island and gave every possible coöperation. Mr. Ford Wilke and Mr. Karl W. Kenyon were largely responsible for the difficult and often dangerous job of marking the seals. Their daily help greatly facilitated the study and, in addition, their extensive familiarity with fur seals gave a perspective to the investigations which would not otherwise have been possible.

SUMMARY

By observing marked individuals and by constructing a mathematical model based on daily censuses of all animals in the study area, the following parameters for the timing of the various activities of female fur seals were obtained: interval between arrival on the rookery and parturition, two days; interval between parturition and estrus, six days; departure for sea, one day after onset of estrus; duration of first trip to sea, five days; duration of second and subsequent trips to sea, eight days; duration of stay ashore between trips to sea, two days or less.

The cows arrive at the rookery during a period of more than six weeks. Since the cows nurse only their own young, the pups go without food for as long as ten days while their mothers are at sea.

The number of females held in a harem at any one time varied between one and 108. The ratio of breeding females to harem-maintaining males was 39:1, but the mean harem size was only 16 because half or fewer of the females were ashore at any one time. The size of a bull's harem is more dependent on the location and topography of his territory than on his vigor.

The female population in the rookery shows conspicuous short-term fluctuations caused by daily variations in weather.

Duration of harem maintenance in the stable harems varied from 18 to 41 days with a mean of 31 days. The shortest periods of harem maintenance were found in those harems which were most accessible to the sea.

Female fur seals are highly gregarious and tend to join harems that are already established. Choice of harem appears to be without reference to the male. Males

which maintain territories close to the water acquire harems before males farther inland.

Territory maintaining males that have no females frequently raid established harems, but such raiding is usually futile unless the male can accumulate four or five females.

Harem bulls regularly search their harems for estrous females which they identify by smell. Typically, a female is copulated with only once during the breeding season. Early in the breeding season the copulation rate of harem bulls is adequate to serve all the females that come into estrus, but females arriving at the rookery late in the season are not adequately serviced by the harem bulls.

The males do not appear capable of adequately servicing a harem of more than 100 females, but otherwise there appears to be no strong relationship between fertilization efficiency and either harem size, duration of harem maintenance, or date of beginning of harem maintenance.

A male's aggressiveness and sexual interest decline markedly at the end of his period of harem maintenance and a male's departure from the rookery is often spontaneous.

The high rate of pregnancy (92 per cent) of pelagically-taken females six to ten years old indicates that virtually all the females are impregnated despite the large number of non-breeding males.

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REPRODUCTION AND AGE STRUCTURE OF A MONGOOSE POPULATION IN HAWAII

By Oliver P. Pearson and Paul H. Baldwin

The order Carnivora is currently divided into ten families. The reproductive habits of members of six of these families have been worked out in some detail, and are surprisingly different in separate families. In view of such diversity it seemed of interest to investigate the reproduction of the mongoose, a primitive carnivore of the family Viverridae (which includes also genets and civets), a family about which little information on reproduction has been reported.

During a year of biological investigations in Hawaii, one of us (Baldwin) was able to collect a series of mongooses in each month. A report on their natural history has appeared elsewhere (Baldwin, Schwartz, and Schwartz, 1952). We are grateful to the committee on the Joseph Henry Fund of the National Academy of Sciences for support of this project and to Dr. and Mrs. Chester K. Wentworth of Hawaii for the use of facilities in the field.

Mongooses were introduced into the Hawaiian Islands from the West Indies in 1883. The stock originally came from India and, judging from our Hawaiian specimens, represents *Herpestes auropunctatus auropunctatus*. It not only has become firmly established on four of the eight Hawaiian Islands, but is extremely abundant in some regions where it occupies the ecologic niche of a small, ground-dwelling predator feeding mainly upon insects, rodents, birds, and some fruits.

Between September 22, 1948, and September 11, 1949, about 144 male and 77 female mongooses were obtained, many in small steel traps but most in drop-door, live-traps baited with cooked meat (hotel scraps). Twenty-three captives were held under observation in cages for periods of a few days to four months. About a dozen males caught in February and not included in the total above were discarded without dissection, as were occasional males later in the year. Live mongooses were handled by means of narrow cones made from inch-mesh chicken wire.

The traps were ordinarily set in lines and spaced at intervals of one-tenth mile. The scarcity of catches of subadult mongooses suggests that the sample may not have been truly random. Possibly the aggressiveness of older individuals, especially males, may have led to their capture more readily than the extremely young (yet one young male was found in a trap with the anxious mother tending it). Even when trap-lines were maintained for many days at a time, permitting many of the older ones to be removed from an area, young did not appear in the traps, hence the young may have been fed in the dens, or they may have foraged close to dens without ranging as far abroad as adults.

Twelve individuals of various ages were marked by ear clippings and released, mostly at the field headquarters, for eventual recapture in connection with ageing studies. Three were caught a second time at the site of their release. The most useful animals for release would have been juveniles, but sufficient numbers were not available.

Specimens were dissected in the field by Baldwin, notes were taken, and appropriate organs were preserved in Bouin's fluid or, in the case of skeletal material, by drying. Further examination of these and of histologic preparations was then carried out in the laboratory, primarily by Pearson.

AGE CLASSES

In anticipation of being able to determine the age of specimens, skulls, humeri, and bacula were saved. Skulls proved to be the most useful and were employed as described below. Although we expected that differences in diet might cause great variation in rate of wear of the teeth, the fact that tooth wear was almost the same in all specimens at a certain stage of suture closure encouraged us to rely heavily on tooth wear when estimating the age of specimens.

The male type series.—After a preliminary survey of the 136 skulls of males, four skulls were picked out that differed by easily-recognizable differences in degree of closure of sutures, development of sagittal crest, and extent of tooth wear. Greatest reliance was placed on tooth wear. These four skulls were designated types for age classes 2, 4, 6, and 8, and have the following characteristics:

Class 2.—Adult dentition; all teeth unworn, cusps sharp. No sagittal crest. Frontal-parietal suture distinct, palatal suture visible in midline of posterior region of palate. Bones not rugose, skull light.

Class 4.—All teeth slightly worn, three cusps on M^1 rounded but distinct. Canines sharp. Small sagittal crest. Frontal-parietal and palatal sutures still visible.

Class 6.—All teeth sound but much worn, no cusps on M^1, canines blunt. Sagittal crest well developed. Frontal-parietal and palatal sutures obliterated. Palate rugose.

Class 8.—All teeth so badly worn, broken, or missing as to be practically useless. Other characters as in class 6.

It was then possible to assign any skull to one of these classes or to intermediate classes

3, 5, and 7 by comparison with the type series. Skulls in which milk teeth were still present were placed in class 1.

Actual age of males.—In the absence of returns from males marked when very young, it has been necessary to use the following indirect method of equating age classes with actual chronological age. Since most mongooses are born either near the middle of April or near the end of July (Fig. 6), one may assume when examining the skull of a specimen taken in August that it is either newborn, about 3½ months old, or more than one year old. There is no difficulty in telling these three age groups apart, and thus one can establish with reasonable certainty what the skull of a 3½-month-old mongoose looks like. Similarly, a skull from early in November must be either 3½, 6½, or 15½ or more months old. If the skull looks slightly older than the known 3½-month specimen, then it must be 6½ months old. By making use of every specimen in this fashion and working from the youngest groups to the oldest, we have been able to match our age classes with calendar age in, we feel, a fairly accurate manner. The accuracy probably diminishes in the older age groups as one recedes from the probable birth date. The relationship between classes and actual age is illustrated in Figure 1.

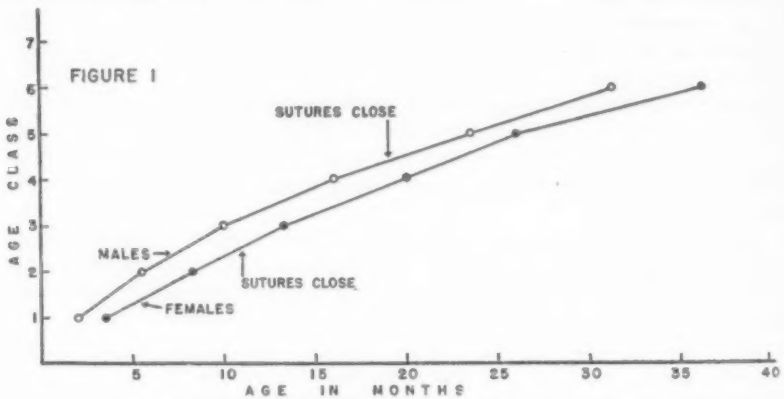

FIG. 1.—Relation between age classes and estimated age of males and females as determined by examination of skulls. For method of constructing the curves, see text.

Actual age of females.—The skulls of 74 females were sorted into eight age classes by comparison with the four type male skulls. Certain differences became apparent. In most females the frontal-parietal suture disappears between age classes 2 and 3, judging by toothwear, while in most males it does not disappear until between classes 4 and 5. The epiphysis at the head of the humerus also fuses at these times, respectively, in the two sexes. Furthermore, when actual ages of the females are calculated by the method explained above for the males, it is found that a female of class 2 is eight months old, whereas a male of class 2 is only six months old. At class 3 the females are 13 months old while the males are only ten. These differences, illustrated in Figure 1, mean that the teeth of the males wear more rapidly than those of the females, and that the frontal-parietal and humeral sutures close earlier in life in the females (11 months) than in the males (19 months).

A frequency distribution of age classes of males and females (Fig. 2) reveals further interesting differences between the two sexes. The males fall into a rather orderly distribution with the mode at class 6 (31 months) and the mean at class 5.20 (25 months). The mode for the females is at classes 5 and 6 (26–36 months) and the mean at class 4.36 (22 months). This means that the female population averaged slightly younger than the male population. This is partly due to the surprisingly large proportion of females in class 2, but also to the

scarcity of females in classes 7 and 8. Actually, the large number of old males is noteworthy rather than the scarcity of old females. Ten per cent of the males fall into class 8, which may be described as practically toothless. In most of these the incisors are completely gone, the canines mere stumps, and, in many, the molar surfaces have worn completely away leaving three small pegs, the roots, which scarcely could have protruded above the gums. In one specimen of normal weight, the only teeth on one side of the upper jaw were the canine, which projected less than 3 mm. from the bone, and the peg-like root of the second molar, which projected less than ½ mm. Conditions on the other side of the jaw were little better. The survival of so many aged individuals in a wild population is remarkable.

Comparison of the age structure of the mongoose population with that of a population of mountain viscachas (a species of approximately similar size and about which age characteristics are known) reveals great differences. The mountain viscacha has a yearly reproduction potential about half that of the mongoose, and the young, unlike those of mongooses, are precocial at birth. About half of a population of viscachas is *less* than one year old (Pearson, 1948), whereas among our sample of mongooses, despite their higher reproduction potential, about three-quarters of the individuals are *over* one year of age. This situation suggests either an absence of young mongooses due to faulty sampling of the

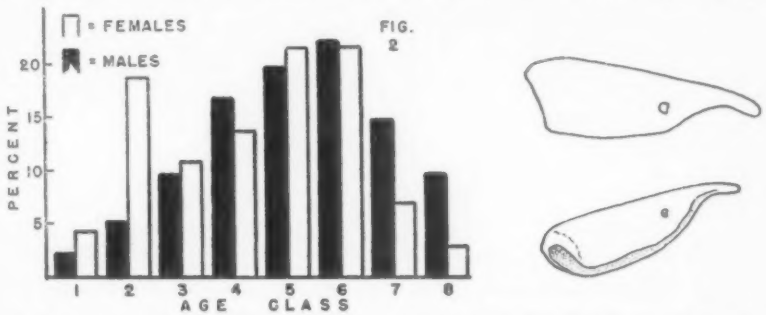

FIG. 2.—Percentage of males and females in each age class. FIG. 3 (RIGHT).—Baculum of an adult male. 3.2 ×.

population, a relatively high mortality of the altricial young of the mongoose compared to the viscacha, or unusual longevity of aged mongooses (possibly a result of scarcity of competitors or of predators in the Hawaiian Islands).

THE MALE

The anatomy of the male reproductive tract is not unusual. The testes are of a size and proportion found in other carnivores of similar body size. In adults the testes are scrotal and cannot be pushed back into the body cavity. Even in a six-ounce male about two months old they were in the scrotum and could not be retracted. Seasonal fluctuations in testis size are outlined below. The penis is laterally compressed, the urethra opening by a longitudinal 3-mm. slit along the postero-ventral edge. The penis is supported by a baculum shaped like a claw (Fig. 3), the sides of which fold down and have a considerable depth so that the urethra is almost completely surrounded by bone. There is frequently a notch in the ventral margin of each side or, as in the illustration, a foramen on each side. In adults, the baculum reaches a length of 12 mm. and a depth of 5 mm. A young individual approximately 2 months old had a baculum 3 mm. long, and another individual less than three months old had a slender baculum 6 mm. long. It reaches adult size at some time between six and 20 months of age.

As in many other carnivores, seminal vesicles are lacking. The prostates, conspicuous

glandular bodies lying on both sides of the urethra between the base of the bladder and the anterior edge of the pubic symphysis, open into the urethra by three pairs of short ducts. A slight seasonal fluctuation in size is described below.

About 2 cm. posterior to the prostate glands, and immediately posterior to the crus penis, lie the bulbo-urethral glands. Each of the two glands is heavily invested by muscle so that it appears as a muscular ovoid, about 15 by 9 mm. in adults. Each gland opens into the urethra by a single short duct at the base of the penis.

As in other species of mongooses, the anus is surrounded by a hairless pouch of skin. A gland on each side of the anus opens by a short duct into the side of the pouch. One of the anal glands of an old male, on September 11, measured 8 x 7 x 5 mm.

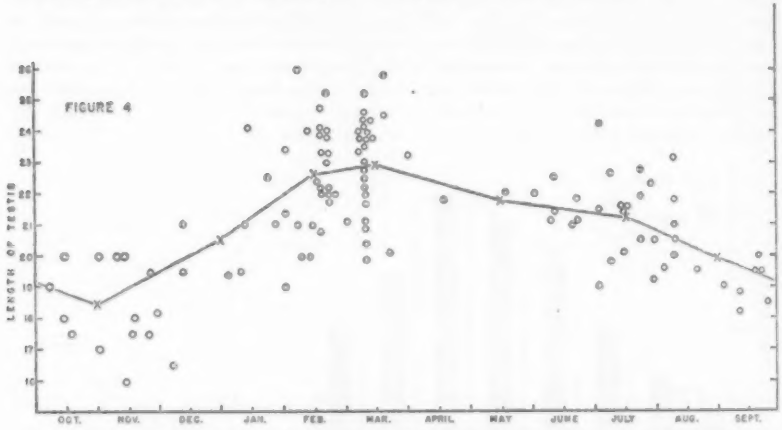

FIG. 4.—Seasonal change in the length of the left testis of adult males of age class 4 or older. The line connects average values for different periods. To obtain samples large enough to yield meaningful averages, the measurements were grouped as follows: October-November, December-January, February, March, April-June, July, August-September.

Seasonal cycle of the testis.—Testes of a young male between one and two months old were 8 mm. long. These were the smallest encountered. Testes of young of both the first and second litter grow throughout the summer and autumn, and soon display considerable mitotic activity. The testes of a second-litter male on September 28 contained a few spermatogonial divisions, but nothing more advanced than primary spermatocytes. This individual had testes 11 mm. long and was about two months old. A first-litter male about 3½ months old on July 30 had testes 12.1 mm. long that contained many early prophases but no stages beyond primary spermatocytes. Another first-litter male about four months old on August 21 had testes 14.5 mm. long that contained all stages of spermatogenesis and spermiogenesis, including spermatozoa. In other words this first-litter male with testes 14.5 mm. long was becoming sexually mature at about four months of age despite the fact that no females would be ready to mate until the next spring some six months later. All males with testes larger than 13 mm. contained spermatozoa. The smallest testis containing spermatozoa measured 10.5 mm., and was from a young male taken on January 12. Only a few spermatozoa or advanced spermatids were present.

Once the testes of young males have become mature in late summer or in the autumn, they contain spermatozoa and all stages of spermatogenesis for the rest of the life of the individual (Fig. 5). All testes that were examined of males ten months (age class 3) or more old were in active spermatogenesis, including those of an old individual of age class 8.

Despite this ability to produce spermatozoa in every month of the year, the testes of

adults undergo a slight but definite seasonal fluctuation in size. Figure 4 illustrates this cycle using testis size of 114 adult males more than a year old (age class 4 or older). Maximum size is reached in February and March at the beginning of the breeding season. The seminiferous tubules are larger in diameter at this time and contain more spermatozoa than in the autumn. Moreover, the epididymis is smaller in the autumn, so it is likely that fertility of males is reduced at this season. A male gonadal cycle of this kind, combining size fluctuation with continual spermatogenesis, has seldom been reported among wild mammals.

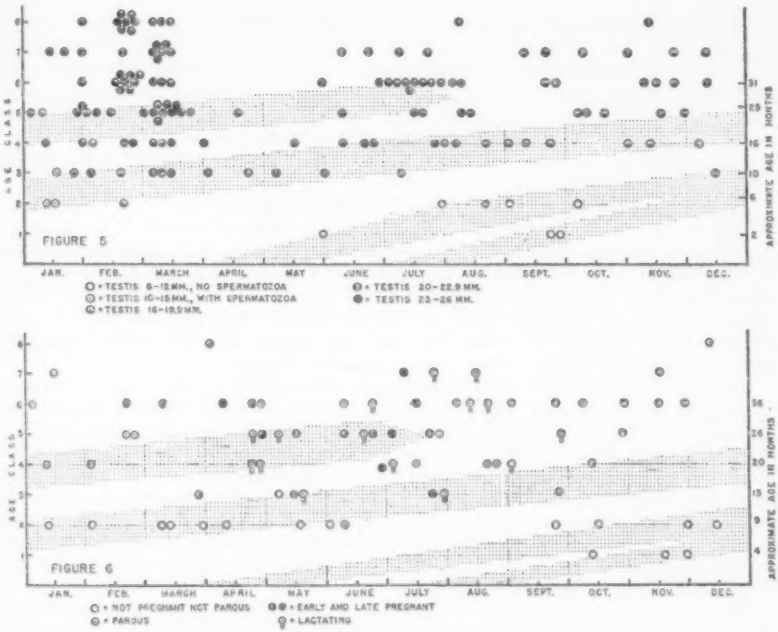

FIG. 5 (TOP).—Age structure of the male population throughout the year, and condition of the testis. Measurements given are lengths of the left testis. FIG. 6 (BOTTOM).—A graphic synopsis of the reproduction and of the age structure of a population of mongooses throughout the year. Each circle represents a single female. The sloping stippled bands facilitate following the maturation of the spring and summer litters until about two years of age. Females were judged parous on the basis of size and condition of uteri and nipples.

Growth and seasonal cycle of the prostate gland.—Size of the prostates was recorded for only a portion of the specimens. The glands were exposed by pulling the bladder ventrally and caudally; the measurement taken was the distance transversely across both glands. The smallest gland measured was 5.5 mm. This was on October 7 in a male about 5½ months old with 11.2 mm. testes. Spermatogenesis had proceeded to the primary spermatocyte stage. Another male, somewhat younger, had 8 mm. prostates on July 30 associated with 12.1 mm. testes containing secondary spermatocytes. A third male about 5½ months old on January 12 still had small prostates 6 mm. across, although the testes contained a few spermatozoa. Other young males in late January and February had prostates 12.7 to 14.5 mm. across, which is as large as in adults. It is concluded that the testes and prostates of

young males become functional in the first spring following their birth, although there seems to be considerable variation in the rapidity of development of these organs in different young males. Possibly those of first-litter males develop disproportionately early.

A slight annual fluctuation in size of the prostate of adults was found, reaching, as in the case of the testes, full size in the spring (as large as 17 mm. but more usually 13 to 15 mm.), and reaching a minimum in the autumn (9 to 12 mm.). Testes larger than 20 mm. were usually associated with large prostates (more than 12 mm.).

THE FEMALE

The female reproductive organs are similar in most respects to those of other carnivores of similar size, such as the mink and ferret, but differ in several details. The uterus is bipartite, with horns usually 20 to 30 mm. long in non-pregnant adults. The corpus uteri, measured externally from the union of the two cornua to the level of the os cervix at the base of the bladder, is from 15 to 40 mm. long, depending upon the reproductive state of the female. The lumen of the corpus uteri is divided by a longitudinal partition for its anterior few millimeters, but for most of its length there is a common canal through which cleaving ova can pass from one uterine horn to the other.

Between the beginning of proestrum and implantation of the embryo, the uterine horns become swollen and turgid throughout their length, reaching a diameter of as much as 6 mm. in specimens with cleaving ova in the oviducts or with early blastocysts in the uterus. The increase in uterine size results from hypertrophy of the uterine glands and myometrium rather than from an accumulation of fluid. After parturition, implantation sites remain visible for weeks or months in many, but not all, females. Such implantation scars were visible as late as January 16, which is at least four months after parturition. In parous females the uterus is usually thicker than in immature females.

The most unusual features of the reproductive tract are the extreme length of the oviducts and ovarian ligaments. The ovary is usually situated considerably anterior to the cephalic end of the uterus. This displacement results in such an elongation of the strap-like ovarian ligament, from the hilum of the ovary to the uterus, that the ligament is sometimes more than half as long as the uterine horn. The oviducts likewise have become elongated. They course from the uterus along one side of the ovary to a point slightly anterior to the ovary, then bend abruptly caudad before flaring to form a fimbriated ostium. In most specimens the oviduct is remarkably free of convolutions and sharp bends; sometimes the oviduct is longer than the uterine horn. The ovary is almost completely encapsulated in a membranous bursa in which the oviduct lies.

The ovaries are relatively small. Among a dozen specimens the range of ovarian weight was from 6 mg., for one ovary of a parous female caught in May, to 31 mg., for one of a pregnant female in March. Right ovaries averaged as heavy as left.

Bartholin's glands are quite large in some specimens, but they were not usually examined. In a specimen in early pregnancy on February 26 they showed conspicuously through the skin lateral and posterior to the vulva, and were larger than the anal glands. In a female in late pregnancy they measured 8 mm. in diameter.

Vaginal smears of two caged mongooses were taken daily, with occasional omission of a few days. These females were captured February 21 and 22, and the smears were made from April 19 until June 28. Neither animal mated during captivity. No smears of predominantly cornified cells were obtained, although a few cornified cells appeared occasionally. Most smears were dominated by leucocytes, with lesser numbers of nucleated epithelial cells. In one of the females, however, the smear contained primarily nucleated epithelial cells from May 10 to 14 and again from May 30 to June 4. In the other females, smears dominated by nucleated epithelial cells appeared from May 10 to 16 and from June 22 to 25. On July 3 the ovaries of this animal contained follicles up to 850 micra in diameter, but no corpora lutea. If the smears of nucleated epithelial cells represent periods of estrus or proestrum, then the absence of corpora lutea in the ovaries of both of these females when they were sacrificed suggests that ovulation does not occur in the absence of the male. It remains to be proven, however, that these females would have ovulated if allowed to copulate.

The vulvar tissue increases in size and becomes puffy at the beginning of the breeding season. In a female that had recently ovulated the vulvar opening was more relaxed on March 27 than in winter specimens, the clitoris was more prominent, and the vulva, which measured 12 mm. across, was more turgid and brighter pink. The vulva of a mid-pregnant and of a recently pregnant, lactating female were also more swollen than in winter specimens.

The season of reproduction.—In India, *Herpestes auropunctatus auropunctatus* is reported to have given birth to young on August 21 (Pocock, 1941, quoting Powell), August 23, April 14, and July 9 (Prater, 1936). In Hawaii, Walker (1948) states that only during the autumn and winter months of October, November, and December are young entirely absent. In our series of specimens the breeding season, as delimited by the presence of pregnant females (Fig. 6), extends from February 22 (a specimen with unimplanted uterine embryo) to July 23. The specimen on July 23 contained a cleaving ovum in its oviduct, so if this pregnancy had continued to term the breeding season would have extended until early in September. Since fertile males are present in all months, the limits of the breeding season are determined by the females.

From inspection of Figure 6 it appears that each adult female has two litters per year. This conclusion is reached because almost every adult female is pregnant or lactating in March and April and also in June and July. The usual birthdate for the first litter appears to be in April, and for the second litter, in July. Ovaries examined at various times in the period of lactation contained no corpora lutea or ripe follicles, so the second estrus must be post-lactational rather than post-partum. One female, caught June 10, had recently experienced post-lactational heat, for she had considerable development of the mammary tissue, as well as new corpora lutea and embryos about to become implanted in the uterus.

Some of the yearlings experience their first estrus so late in the spring that it is probable that many of them bear only one litter in their first season.

Age of maturity of females.—Inspection of Figure 6 reveals that one female of age class 2 was pregnant in June. She probably mated at about nine months of age. Other females of age class 2 taken in March, April, and May had active ovaries with fairly large follicles; presumably these females would have become pregnant by the time they were a year old. Six females of age class 3 were pregnant or parous, and all older than this were pregnant or parous. We conclude that all females mate in the next spring after their birth. From the distribution of points in Figure 6 it appears that young females, especially those born in the second litters of the preceding season, mate later in the spring than do adults. There is no evidence of reproductive failure in extremely old individuals.

Growth of follicles.—The largest healthy follicles in ovaries collected outside of the breeding season are less than 0.78 mm. in diameter. At estrus, follicles enlarge to as much as 1.4 mm. and probably more. Immediately following ovulation, as illustrated by a specimen containing a six-celled tubal ovum, the largest follicles are about 1.0 mm. in diameter, but these become atretic so rapidly that frequently by the time a definite implantation swelling is discernible in the uterus no follicles larger than 0.5 mm. remain. Lactating females contain follicles as large as 0.9 mm., but there is considerable variation depending upon the stage of lactation and upon whether a post-lactational estrus is approaching. The ripe follicles are visible as clear blisters that protrude only slightly from the surface of the ovary. In histologic sections they are similar to follicles of ferrets and mink.

Within fresh ovaries may be seen numerous bright yellow refractive specks that probably represent old atretic follicles. The zona pellucida of the ovum in such follicles persists for a long time.

In the absence of controlled matings of captive mongooses, proof of whether ovulation is spontaneous or is induced by copulation is lacking. However, the histories of the four females kept for a considerable time in captivity are pertinent. These were kept from February 21 to July 9, April 27 to June 24, May 16 to July 9, and February 22 to July 3. On occasion, males were enclosed for a few hours at different times of day with certain of these females, but matings never took place, perhaps because of lack of receptivity of the females due to the

phase of the estrous cycle, or perhaps because of the artificiality of the situation. In the case of one female, several males were placed, one at a time, in the cage with her for overnight periods or longer between March 28 and April 9; later in April, males were again placed in her cage. There is no indication that copulation occurred. Difficulty was encountered in determining heat from external signs, and this may have been mainly responsible for the failure of mating experiments. When killed, these caged females had numerous healthy ovarian follicles up to 1.1, 1.4, 1.0, and 0.9 mm. in diameter, respectively. In every case the ovaries were obviously active, in some cases the ovarian blood vessels and lymphatics were engorged, yet no corpora lutea were present. One must conclude either that the conditions of captivity were not conducive to spontaneous ovulation (and the vigorous appearance of these ovaries makes this seem doubtful), or that ovulation must be induced by copulation, which was not provided. A certain amount of vaginal stimulation must have occurred when vaginal smears were obtained by the pipette method, but apparently this was inadequate to induce ovulation.

Life history of the corpus luteum.—Upon ovulation the follicle collapses but fills out again almost immediately. A small stigma is usually visible macroscopically at this time. The antrum of the growing corpus luteum is filled in by luteal cells to form a solid organ at about the time that the embryo attaches to the uterus. By the time a localized uterine swelling is visible, the corpora lutea are becoming yellow (as seen in fresh ovaries), and have filled out to about 2 mm. in diameter. Later in pregnancy they reach nearly 3 mm. Regression of the corpora is rapid at the end of pregnancy, for in a post-partum female that, judging from the condition of the uterus and mammary glands, must have given birth a few hours before she was trapped, the luteal cells were obviously degenerate and the corpora measured only 0.75 mm. in diameter. In sectioned ovaries of other lactating females, the corpora have either totally disappeared or are represented by mere traces of old luteal tissue. Such old corpora lutea can frequently be recognized as discrete yellow discolorations in fresh ovaries by examination with a hand lens.

Duration of pregnancy.—In the absence of births among captive females, it is necessary to estimate the duration of gestation from the elapsed time between the capture of the first pregnant and the first lactating specimens. Inspection of Figure 6 reveals that the first pregnancies appear at about the end of February and lactation at about the third week of April. This span of seven weeks is the most reliable estimate of pregnancy that we have been able to glean from our data. Pocock (1941, quoting Powell) records a gestation of 43 days for a mongoose of this subspecies in India, and Prater (1936) records a pregnancy lasting seven weeks.

A rough indication of the rate of development of the embryo at different stages is given by the number of specimens taken at each stage. The distribution is as follows: segmenting ova in oviducts, two specimens; early embryos in uterus but not yet implanted, four; post-implantation stages, nine.

Relaxation of the pelvis.—A cycle of ossification of the pubic symphysis to facilitate parturition has been found in several kinds of mammals. The pubic symphysis of two male mongooses of age classes 6 and 7 killed in September was ossified for part of its length. In a younger male (age class 4), on September 23, the two innominate bones, during cleaning, separated without fracture along the pubic symphysis, leaving smooth, undulating surfaces. This symphysis obviously was not ossified.

Among females the pubic symphysis may or may not be ossified, depending upon age and reproductive condition. In a parous female slightly more than a year old (age class 3), on September 28, the symphysis was unossified. In two older females (age classes 5 and 6) near the end of lactation on this date, the symphysis was partly ossified. As in males, ossification was more obvious on the inner aspect, especially at the anterior end. The ilio-sacral joint appeared to be unossified. In a late-pregnant female of age 6 (fetuses 98 to 101 mm. from nose to tip of tail), the pubic symphysis was distinct and completely unossified. Field notes state that the pubic symphysis of this animal was loose and relaxed at the time of dissection. In another female carrying slightly smaller fetuses the symphysis was still

bony. It is concluded that in males ossification of the suture probably occurs between age classes 4 and 6, that it occurs after age 3 in females, that in older females the bony union between the two sides of the pelvis is resorbed and replaced by fibrous or cartilaginous tissue during pregnancy, and that bone is again deposited before the end of lactation.

Lactation.—There are three pairs of abdominal nipples, all of which undergo size changes during the reproductive cycle. The posterior pair is almost always the largest. The posterior nipples of young, non-parous females are very small through the autumn and winter, usually 1 mm. or less long. In adults at this time they are usually 1.5 mm. or longer. The nipples do not enlarge appreciably until pregnancy is well established. The nipples of one female with embryos 20 mm. Crown-Rump had begun to swell and had become pink, as in several other pregnant mongooses. At the height of lactation, nipples may reach a length of 6 mm. Sometimes milk can be squeezed from all three pairs of nipples, while in other specimens the anterior and middle pairs may be dry or may yield only a cheesy substance. The small size of the anterior pair may be correlated with lack of need due to the small average size of litters. At the height of lactation the mammary tissue forms a subcutaneous blanket about 6 mm. thick.

The approximate duration of nursing has been estimated by a method similar to that for estimating duration of pregnancy. The first lactating females were caught near the end of April, and the first parous females no longer lactating appeared at the end of May. This suggests a nursing period lasting four weeks, but it must be admitted that scarcity of specimens and the difficulty of deciding whether nursing has ceased make this figure unreliable. Another method of estimating the length of the lactation period is as follows. The average birthdates of the two litters are about the third week of April and the fourth week of July, 13 weeks apart. If post-lactation estrus and pregnancy begin a week after lactation ceases, as in the ferret, and if pregnancy lasts seven weeks, then a period of five weeks remains for lactation. Judging from capture of a lactating female and a young male in front of the same den, the young nurse until they weigh at least six ounces and have a length (head and body) of at least 200 mm.

Fecundity.—In India *Herpestes auropunctatus auropunctatus* has produced litters of three (Pocock, 1941, quoting Powell), two, two, and three (Prater, 1936). In Hawaii, Walker (1948) reports that there are usually two young to a litter, and that, of several score of family groups observed, only one female was seen with triplets. Bryan (1908) writes that he found a female mongoose with a flourishing family of five young in a hole that it had appropriated from a nesting Hawaiian dark-rumped petrel (*Pterodroma phaeopygia sandwichensis*) on Molokai. Among nine females in our series the number of macroscopically distinct uterine swellings varied from two to four with an average of 2.7. Thirteen of these fetuses were in the right horn and 11 in the left, never more than two per horn. Judging by number of implantation scars, a less reliable method but one for which more cases are available, the average number of implantations in 19 females with especially distinct scars was 2.4; the range was from two to four. When the average number of scars for a larger series of females (35 individuals), including those with scars of more indistinct character (and hence of more uncertain number) was calculated, the average was also 2.4 scars per female. A count of corpora lutea in 16 females revealed an average of 2.7 per female with a range from one to four, in no case more than three in one ovary. Ovulation was as frequent in right as in left ovaries.

To reveal some of the loss of ova following ovulation a comparison was made of the number of fetuses and corpora lutea in the same individuals. This comparison revealed that 24 ruptured follicles resulted in 21 macroscopically visible uterine swellings, or a loss of 12 per cent of the ova shed. It also disclosed that ova from one ovary frequently cross over and become implanted in the opposite uterine horn.

Thirty-one females in our collection were either pregnant, or were lactating and possessed clear implantation scars. In other words, each of 31 females was without doubt experiencing a fertile reproductive cycle. In contrast, only one female was discovered that had ovulated but was not known to be pregnant or lactating. This specimen had a single young corpus

luteum, and uterine horns similar to those of other specimens with pre-implantation embryos. No ovum or embryo was found in serial sections of the oviducts and uteri. She may, therefore, represent the only case of pseudopregnancy among 32 specimens in which this possibility existed, or she may actually have been a pregnant female in which the single fertilized ovum escaped detection.

Post-implantation mortality does not seem to be great, for no fetuses were being resorbed in the nine females with macroscopically visible embryos. However, a female caught on April 29 and kept in a cage until her death on May 14 had resorbed her two fetuses.

Discussion.—Upon comparison with the reproductive cycle of other Carnivora, the cycle of the female mongoose resembles that of the ferret most closely. The two animals are similar in such basic features as: reproduction in spring and summer, production of more than one litter per year, maturation of males and females in their first year, lack of postpartum estrus and lack of corpora lutea of lactation, short gestation with prompt implantation of the blastocysts, and, probably, induced ovulation. The mongoose cycle is unspecialized, conservative, perhaps primitive. It lacks the unusual specializations of some other carnivores, such as superfetation (mink), delayed implantation (fur seal and many Mustelidae), ovulation of primary oocytes (dog and fox), and masculinization of external genitalia of females and dominance of one ovary at ovulation (hyena). The male mongoose differs from the male ferret in having continual spermatogenesis throughout the year.

Although information on *Herpestes auropunctatus* in its native region is meager, it appears that with respect to breeding season, litter size, and gestation period, the behavior of this mongoose in India and in Hawaii is similar.

SUMMARY

Two hundred and twenty-one mongooses (*Herpestes auropunctatus auropunctatus*) were trapped during a single year from the Island of Hawaii.

Relative ages of specimens were determined, using as criteria the degree of closure of sutures, development of sagittal crest, and extent of tooth wear. Actual ages of specimens were estimated by correlating skull age with the probable birth date; this procedure was possible because most mongooses are born either near the middle of April or near the end of July. The teeth of males wear more rapidly than those of females, but the frontal-parietal sutures close earlier in life in the females (11 months) than in the males (19 months).

The mean age of 136 males was 25 months, whereas the mean age of 75 females was 22 months. Tooth wear in 10 per cent of all males had progressed to the point where the grinding surfaces of most molars were completely gone, the canines were mere stumps, and the incisors had disappeared. About three quarters of all individuals trapped were over one year of age. However, it is possible that the very young were not adequately represented in the sample.

The male reproductive tract is typical of small carnivores. The testes produce spermatozoa as early as four months after birth, though breeding would necessarily be postponed until the following spring for lack of estrous females. Sperm production, once initiated, is continuous throughout life; nevertheless, testes and sex accessories of adults are slightly larger in spring than in autumn.

The female reproductive organs resemble those of the mink and ferret, with differences in details. The ovaries are situated considerably anterior to the cephalic end of the uterus. Cleaving ova sometimes pass from one uterine horn to the other. After parturition, implantation scars may remain visible as long as four months.

Vaginal smear pictures from isolated captive females plus the failure of corpora lutea to appear in non-mated captives suggest that ovulation does not occur in the absence of copulation. Corpora lutea reach maximum size in mid-pregnancy; regression is rapid at the end of pregnancy, and in lactating females mere traces of luteal tissue remain.

Early-pregnant females were taken from late February to late July, indicating that the breeding season, as delimited by the presence of pregnant females, extended into September. Females may bear two litters per year; the second estrus is post-lactational. One young female had mated at about nine months of age. All females mate in the next spring after birth.

The estimated duration of pregnancy is seven weeks.

In adult females, the bony symphysis pubis is resorbed during pregnancy, and bone is again deposited, reuniting the symphysis, before the end of lactation.

There are three pairs of abdominal nipples; the posterior pair is usually the largest.

The number of fetuses in nine females varied from two to four, and averaged 2.7; the number of implantation scars in 17 females ranged from two to four, and averaged 2.4. In 16 females the number of corpora lutea ranged from one to four, and averaged 2.7. Twelve per cent of ova shed were lost. Post-implantation mortality seems to be slight.

The reproductive cycle of the mongoose in Hawaii resembles that of the ferret most closely among animals whose reproductive characteristics are well known. The mongoose cycle lacks various specializations seen in other carnivores, and perhaps is primitive.

LITERATURE CITED

Baldwin, P. H., C. W. Schwartz, and Elizabeth R. Schwartz. 1952. Life history and economic status of the mongoose in Hawaii. Jour. Mamm., 33: 335–356.

Bryan, W. A. 1908. Some birds of Molokai. Occas. Papers, Bernice P. Bishop Museum, 4(2): 133–176.

Pearson, O. P. 1948. Life history of the mountain viscachas in Peru. Jour. Mamm. 29: 345–374.

Pocock, R. I. 1941. The fauna of British India, Mammalia. Vol. 2. Taylor, London, 503 p.

Prater, S. H. 1936. The wild animals of the Indian Empire. Jour. Bombay Nat. Hist. Soc., 38 (supplement): 189–215.

Walker, L. W. 1948. Citizen mongoose. Audubon Magazine, 50: 80–85.

Museum of Vertebrate Zoology, University of California, Berkeley, and Department of Zoology, Colorado A & M College, Fort Collins. Received August 4, 1952.

HOME RANGE, TERRITORIALITY, AND POPULATIONS OF THE CHIPMUNK IN CENTRAL NEW YORK

By Ralph W. Yerger

In recent years many investigators have studied the behavior of animals under natural conditions. Although our knowledge of home range and territoriality among many species of mammals is steadily increasing, more studies are needed from different localities within the range of any particular species. Results of such investigations will contribute to our knowledge and understanding of population dynamics.

The chipmunk is widely distributed throughout the eastern United States, yet in spite of its abundance it has been neglected to a large extent by mammalogists, and we are familiar only with the general aspects of its life history. The purpose of this investigation was to determine the size of the home range of the eastern chipmunk, *Tamias striatus lysteri* (Richardson), in central New York, and to study the role that territoriality plays in its behavior pattern. Additional contributions to the life history of the chipmunk were obtained incidentally, and will be discussed elsewhere.

Field work was conducted from June 14 to November 13, 1949, and from March 25 to July 15, 1950, around the shores of Beebe Lake, on the Cornell University Campus at Ithaca, New York. This artificial lake (elevation 870 feet) occupies the basin of an excavated interglacial gorge, and has been formed by impounding the waters of Fall Creek which have cut a postglacial channel across this Pleistocene feature. The slopes that border the lake are moderately steep, rising, on the average, 50 feet in a distance of 100 feet, and in some places are even more abrupt. The second growth woodlands belong to the maple-beech association, with oaks, hickories, and hemlocks also present in some numbers. Rock piles, stumps, logs, brushy cover, and abundant food supplies combine to form ideal chipmunk habitat. The most favorable areas for study were on the north and south shores, and comprised a total of 11.1 acres. The woods surrounding the lake were sharply set off from open grassy areas and campus installations.

Other mammals trapped or observed on the study area included *Sorex cinereus cinereus*, *Blarina brevicauda talpoides*, *Mustela erminea cicognani*, *Mustela frenata noveboracensis*, *Tamiasciurus hudsonicus loquax*, *Sciurus carolinensis leucotis*, *Glaucomys volans volans*, *Peromyscus leucopus noveboracensis*, *Microtus pennsylvanicus pennsylvanicus*, and *Sylvilagus floridanus mearnsi*.

Methods.—Chipmunks were captured solely by live-trapping. In 1949, small-sized Sherman traps proved satisfactory for young animals, but adults frequently ate all of the bait from the trap and evaded capture. Several larger Sherman traps were more successful. In 1950, a hardware cloth trap with inside dimensions of $8\frac{3}{4}''$ x $2\frac{1}{2}''$ x $2\frac{1}{2}''$ was used with much greater success. This type was operated by a large treadle that, when depressed, allowed the door to swing shut by gravity. It also provided complete ventilation, a decided advantage during hot weather when animals confined in Sherman traps for any length of

time suffered if the trap was exposed to the direct rays of the sun. The traps were placed in shaded sites whenever possible and protected only by a few dry leaves thrown over the top. No nesting material was used at any time. Trap lines were set in the early morning and checked twice a day, once at noon and again at sundown after the chipmunks had retired to their burrows for the night. Sunflower seeds were the most satisfactory bait. Trap mortality was negligible as far as chipmunks were concerned. Six chipmunks taken from the traps during morning checks were in a much weakened condition. In each case, the animal had been captured and released the previous evening, then had reentered a trap in which it spent the night without any protection. Only one of these animals died from the exposure.

The widely used method of placing traps in a grid pattern was not followed in this study. In the first place, the steep slopes and embankments on the area were poorly suited for the employment of this method. Secondly, it was believed that a more complete knowledge of the individual's home range could be determined by changing the trap locations with each new trap line. Finally, the data accumulated from trap captures were to be supplemented with observations of marked animals. The use of grid-trapping techniques in home range studies is of doubtful value in view of several recent studies. Hayne (1950) has demonstrated that the size of the home range in *Microtus p. pennsylvanicus* is related to the distance used between traps. He concludes that the home range of an animal probably cannot be determined by setting traps in a grid pattern. In his study of *Citellus tridecemlineatus* in Michigan, Evans (1951) discovered that grid trapping was far less effective than burrow trapping when he attempted to capture and mark all the individuals in a population.

Trap lines of from 30 to 50 traps covered an area two to three acres in size. Traps were placed in irregularly parallel lines, and from 15 to 80 feet apart. In those areas where chipmunks were especially abundant, traps were placed closer together in order to capture as many animals as quickly as possible. Stumps, logs, nut trees, burrow entrances, and other favorable sites were selected for trap locations, but the areas in between these sites were not neglected. Trap lines were left in position for three days, generally, then reset in another area. In this manner, each portion of the study area was retrapped at intervals throughout the season of chipmunk activity.

Additional records on the extent of home ranges and on movements and behavior of marked animals were obtained by many hours of observation in the field with the aid of eight-power binoculars. All of the information relating to territoriality was secured in this manner.

Each chipmunk was permanently marked by a combination of clipped toes and ears. The toes on the front feet were numbered from one to eight, while those on the hind feet were numbered in tens from ten to one hundred. One series of 109 animals was marked by toe clippings only; a second series (designated the RE series) was marked in the same manner, but, in addition, the top half of the right ear was cut off; a third series (LE) utilized the same toe marks and the top of the left ear. Marking was done at the point of capture without

the use of anesthetic, and resulted in no infections and little discomfort to the animal. A total of 218 chipmunks was marked during the course of the study.

To make it possible to identify an individual chipmunk by observation from a distance, a system of visual marks was developed. Initially, various kinds of colored lacquers, enamels, and textile dyes were used, but none of these color marks persisted longer than ten days to two weeks. The only successful method was to clip patches of fur from various parts of the body or tail. By cutting off the distal portion of the hairs, the dark basal portions formed a distinctive dark patch. These markings included the nape, middle of back, rump, shoulders, flanks, hind legs, and various tail marks. Using these marks singly or in combinations, all the animals in one series could be differentiated from each other. Since the clipped ear of the RE and LE series could easily be seen as a field mark, the same combinations of fur clippings could be used for each of the three series. These markings were obliterated when the animal molted, and the chipmunk had to be recaptured and re-marked. Nevertheless these marks persisted over a longer period of time than any of the colored marks that were attempted. With eight-power binoculars, an observer can readily identify an individual chipmunk with certainty at distances up to 50 feet, or even farther under favorable light conditions. All doubtful identifications were discarded and not included in the records.

At the time of initial capture, the number of the animal, sex, markings used, approximate age, breeding condition, stage of molt, and exact point of capture were recorded. This information was later transferred to permanent records. Upon subsequent captures and observations, similar data were added to these case-history sheets, one for each marked animal. A separate map for each individual was used in plotting the home range as determined by trapping records and observations.

HOME RANGE

Burt (1943) has defined home range as "that area traversed by the individual in its normal activities of food gathering, mating, and caring for young." The desirability of differentiating weekly home range from monthly, seasonal, or yearly home range has been stressed by Mohr (1943, 1947) who summarized about 120 titles which deal with population densities and home ranges of 60 species of North American small mammals. However, only a few of these papers concerned *Tamias striatus*.

Seton (1929) made one of the earliest references to the home range of this species, and stated the belief that a chipmunk ordinarily stayed within an acre of ground, although on occasion it might wander 100 to 200 yards away from the burrow site. Allen (1938) noted certain individuals that traversed a distance of about 200 paces, and one animal regularly gathered food at a pond 400 paces from its den. In southern Michigan, Burt (1940) indicated that the home ranges of four adult females averaged 80 yards in greatest diameter (1.04 acres) and that of two adult males, 112 yards (2.04 acres). In northern Michigan, Blair (1942) found the monthly home range of adult females to be 2.15 ± 0.38 acres; of adult males, 2.31 ± 0.30 acres; of immature females, 1.78 ± 0.18 acres; and of immature males, 2.68 ± 0.48 acres. He found no significant difference in size of home range between sexes or age classes during his study, which lasted only from August 25 to September 22, 1940. Manville (1949) studied *Tamias striatus griseus* in northern Michigan and calculated the home ranges of seven individuals, which varied from 0.19 to 0.43 acres, and averaged 0.25 acre. In this instance, the home ranges of the females averaged 50 per cent higher than that

of the males. His observations were based on trapping periods of five days duration, and extended from May to August. In his study of a small woodlot in central New York, Smith (1942) calculated the home range of four groups of chipmunks: adult males, 3.10 ± 0.41 acres; adult females, 1.66 ± 0.19 acres; immature males, 1.43 ± 0.45 acres; and immature females, 2.04 ± 0.44 acres.

Various methods of calculating home range have been used. The three general types have been discussed by Hayne (1949) who suggested an additional way of stating trapping results. Mohr (1947) concluded that the minimum-home-range method, which involves the connecting of all outlying points of capture into a polygon, gives more consistent and reliable

TABLE 1.—*Home ranges of individual eastern chipmunks*

ADULT FEMALES		ADULT MALES	
No. of captures and observations	Size of home range in acres	No. of captures and observations	Size of home range in acres
15	0.22	14	0.66
12	0.61	12	0.29
11	0.10	10	0.63
10	0.25	10	0.24
10	0.21	9	0.59
8	0.21	8	0.36
8	0.47	8	0.14
8	0.40	8	0.52
8	0.11	7	0.16
7	0.14	7	0.24
7	0.15	7	0.20
7	0.16	6	0.41
7	0.25	6	0.31
7	0.34		
7	0.34	JUVENILES	
6	0.19		
6	0.16	No. of captures and observations, and sex	Size of home range in acres
6	0.34		
6	0.23	♀7	0.12
		♂6	0.19
		♀6	0.18
		♀5	0.10
		♀5	0.18
		♂4	0.32
		♂4	0.26
		♀4	0.11

results than variations of the other methods. For this and other reasons to be discussed, the minimum-home-range method was adopted in this study.

Only those records of adult chipmunks with a total of six or more captures and observations were used in the calculation of home range. Several records with more than this minimum number of entries were discarded because they obviously did not represent the complete home range of the animals. In the case of juveniles, no records were used with less than four captures and observations. No distinction was made between the sexes in the latter group as only a few records were available.

The home ranges of adult females, adult males, and juveniles are shown in Table 1. Table 2 is a summary of the data for the various sexes and age classes, and shows the minimum and maximum sizes of home ranges. In this study it is apparent that adult males have

a slightly larger home range than adult females, and that the home range of young and immature animals is smaller than that of the adults.

The size of the home range of the chipmunk as determined in this study is considerably smaller than those listed by any previous worker except Manville (*op. cit.*). There seems to be a number of reasons for this low figure. First, calculations by the minimum home range method yield more conservative figures than does either the boundary-strip method or the points-of-most-distant-capture method. Mohr (1947) and Manville (*op. cit.*) have pointed out this fact. Second, the many factors which influence the size (and shape) of a home range (Blair, 1940) are so variable in themselves that the sum total of all of them is certain to produce far different results. This is particularly true when such studies are pursued in widely separated localities within the species' geographic range. Third, the abundance of food and cover in the Beebe Lake area together with the high population of chipmunks on the tract would presumably discourage excessive or distant movements of an individual.

Possible criticisms of this study are that the minimum number of records (six) used in calculating an individual's home range is too low, and that larger home ranges would have resulted if a larger number of observations had been used. This might be true if trapping records alone were used, but since these were employed in conjunction with observations of marked animals, I feel that the results, for adult animals at least, give an accurate picture of the minimum home range of the chipmunk in this particular area.

TABLE 2.—*Average size of home ranges of eastern chipmunks with standard errors and extremes*

AGE	SEX	NUMBER OF INDIVIDUALS	AVERAGE NUMBER OF CAPTURES & OBSERVATIONS	SMALLEST HOME RANGE IN ACRES	LARGEST HOME RANGE IN ACRES	AVERAGE SIZE OF HOME RANGE IN ACRES
Adult	Female	19	8.2	0.10	0.61	0.26 ± 0.03
Adult	Male	13	8.6	0.14	0.66	0.37 ± 0.05
Juvenile	Male & Female	8	5.1	0.10	0.32	0.18 ± 0.03

It is generally agreed that the home range of a wild animal is not a well-defined plot of ground with permanent fixed boundaries, but rather that the size and shape generally changes more or less continually from week to week, season to season, and year to year. In view of this constant change, it would appear that biologists can define but not measure an absolute or "true" home range of an animal. It would be far more practical simply to use the term "home range" as Burt has defined it, and realize that its size is determined by calculations based on data obtained by trapping, observation, or other means during a given period of time. For most purposes, it is more important that we have an index of the size of the home range of a certain species in a given area that can be compared to the home range of the same species in another part of its range, or even to the home range of another species. These comparative data would have more value than a theoretical figure such as "absolute" home range. Since the minimum home range method furnishes comparative information, it seems to me to be the most useful one for this phase of life history studies. Of course it is essential that we standardize definitions of terms, and recognize the limitations of the minimum home range method.

Overlapping of home ranges has been widely observed and reported. Blair (1942) found broad overlapping of home ranges of chipmunks among all age groups and sexes, except for breeding females, which he believed possibly excluded other breeding females from their area. In the present study, chipmunks of all ages and both sexes, regardless of the breeding condition, commonly invaded the home ranges of other individuals. It was not unusual for the home ranges of as many as six animals to overlap in a given area. This situation would be expected where the population density was as high as that in the Beebe Lake area, especially since the chipmunks under observation did not exhibit strong territorial behavior.

The only specific information on chipmunks shifting their home range has been given by Burt (1940), who concluded that such movements are found among young animals and adult males, and that old females rarely shift their home sites once they become established. He records animals moving from 225 to 700 yards away from the original place of capture.

In the Beebe Lake area, any movement of 100 yards or more was regarded as a significant change in home range, providing all subsequent captures were in the new area. Three young and three adult male chipmunks were observed to have shifted their home range from 105 to 250 yards away from the original point of capture. Not one female was found to have made a similar move. This is a striking resemblance to Burt's observation where seven of the eight animals cited were males, and the eighth was a young female which showed the least movement. Male chipmunks seem to have a much stronger tendency to shift their home ranges than do females. In the present study, three young males changed their home site in spring when they were one year old, or when they became sexually mature. The few records preclude a generalization, but the fact that all three of the adult males which moved their home range effected this change in late May or early June points to a possible correlation in time with the appearance of the first young of the year above ground.

Burt (*op. cit.*) stated that one-third or more of the animals may be expected to move from the point of original capture. In this study, the six individuals mentioned above are but a small fraction of the population. The great majority of animals were repeatedly captured throughout the course of the study on the same area. Further evidence for the permanence of home sites is furnished by the series of chipmunks marked by Brina Kessel in the fall and spring of 1947–48 on the present study area. Four (two males and two females) of the fifteen animals were recaptured during this investigation, 12 to 16 months later. Each one was occupying the same area as at the time of original capture.

There was no evidence of chipmunks moving from one side of the lake to the other. In fact, the maximum distance any individual moved on either side of the lake was estimated to be not more than 250 yards.

TERRITORIALITY

Many studies have demonstrated that territoriality is a common behavior pattern among many different species of mammals, either throughout the greater portion of their life cycle, or at least during a limited part of it. Burt (1943) carefully distinguished between the concepts of territoriality and home range. A territory is that part of the home range which is protected from other individuals of the same species, either by fighting or by aggressive gestures. He recognizes two fundamental types of territoriality in mammals; one concerns breeding and rearing of young, the other, food and shelter. Trapping records can give only indirect evidence of territorial behavior; only by direct observation can the presence or absence of territoriality be conclusively established. In a later paper, Burt (1949) outlined the biological significance of territoriality to the individual and to the species as a whole.

Examples of territorial behavior among the sciurids have been described by Gordon (1936), Klugh (1927), Clarke (1939), Allen (1943), and others. In his study of the least chipmunk, *Eutamias amoenus affinis*, in the Cascade Mountains of Washington, Broadbooks (*in litt.*, December 31, 1949) determined that a defense of territory was exhibited by breeding females around the immediate vicinity of the den. Allen (1938) found no evidence of territorial behavior in the eastern chipmunk, but antagonism between individuals of this species has been noted by Fraleigh (1929), Harper (1929), Blair (1942), and Manville (1949). Burt (1940) observed that an old female chipmunk displayed territoriality when she defended that part of her home range immediately around her den site. Smith (*op. cit.*) believed that some degree of territorial defense was manifested, at least during the rutting season.

The high population on the study area afforded an excellent opportunity for observing numerous incidents where one chipmunk chased or pursued another. This behavior is the type of antagonism which has frequently been reported in the literature, although some of it is probably no more than the playfulness expressed by groups of young animals, similiar

to the play of small puppies and kittens. These chases reach a peak in the fall (late September and October) when the woods are filled with second litter young, juveniles of the first litter, and adults. This activity undoubtedly accounted for early naturalists mistaking this time of year for the rutting season (Rhoads, 1903).

The determination of the age and sex of the individuals engaged in these encounters was made by means of the distinctive marks (fur and ear clippings) described previously. Because of their very rapid movements, however, a pair of marked animals ran within a few feet of the observer on many occasions and yet could not be identified.

Several observations seem worthy of mention. On April 30, 1950, a lactating female was trapped and released on the eastern side of a small ravine. It ran across a log to the opposite side of the small stream and moved along the bank towards a stump. Suddenly another lactating chipmunk appeared and aggressively chased the first one back across the stream. The attacker remained in a crouched position on a small log for at least five minutes, as if on guard against any further intrusion. The first animal then proceeded towards her own home site, about 45 feet east of the stream.

On another occasion, May 20, 1950, an immature male was captured and released on a slope above a flat, wooded area with numerous fallen logs. This animal ran down to the bottom of the slope and jumped onto one of the large logs. Immediately another immature male charged towards the intruder, chased it away, and then ran back to the other end of the log. A few minutes later, the first chipmunk again climbed on the log, and was promptly chased off by the belligerent defender. In a few minutes the latter ran about 30 feet away, whereupon the intruder finally climbed back on the log without further disturbance. Both of these males were born in August, 1949, and were originally captured and marked on the same day, October 16, 1949. The home range of the intruding chipmunk was confined to the slope for the most part, while the home range of the defender was on the level area, but with considerable overlap on the slope.

The most savage battle witnessed in this study occurred on June 18, 1950, between an adult female, which had recently finished nursing a spring litter, and a subadult male which had been born, presumably, in the summer of 1949. The progress of the chase covered a distance of about 40 feet, from the territory of the female westward to the home range of the male. The two animals jumped at each other violently, the female taking the initiative most of the time. They bit each other savagely, jumped into the air, locked together and fell to the ground, rolling over and over many times. They separated for a few seconds, and then renewed the combat within a short time. The male finally moved into his own home range area, and the female returned to her territory. This conflict is presumed to have been related to courtship behavior, for at this period some of the females were again receptive and ready to mate. It is not unusual for the male and female to fight during this period. Allen (1938) has described the battles which raged between a captive male and female from early February until late March when the female at last became receptive. The females appear to determine when successful mating will occur.

Another brief encounter was noted between an adult male and a female which had recently finished nursing. The male made one quick lunge at the female who moved rapidly downslope towards her home site. The male returned to the center of his home range. This incident took place at the extreme corner of the female's recorded home range.

These observations are similar to the manifestations of territorial behavior witnessed among many other species of animals, both vertebrates and invertebrates. This behavior pattern may not be as conspicuous in the chipmunk as in some other species of mammals, but it appears to play a definite role in the life history of this species. Defense of territory may be observed less frequently among chipmunks since these animals spend much of the day in an underground burrow, and thus do not sight intruders frequently. It is apparent that territoriality may exist even when there is broad overlapping of home ranges of several individuals. These incidents indicate that breeding females are not the only groups of chipmunks to display territorial behavior, rather this behavior pattern is found among both sexes and among all age groups, with, perhaps, the exception of the youngest animals.

Burt (1940) reported that the defended territory of an adult female was 50 yards in radius around the nesting site, while the home range of this individual extended 100 yards or more from that point. In the present study, the home ranges of chipmunks were much smaller than this, and, consequently, territories were also on a smaller scale. Many more observations would be necessary to determine the average size of this defended area.

POPULATIONS

Since population pressure may markedly influence the size of the home range of an individual, it is desirable to have some measure of the population density during the course of a home range study. It is well known, that, in a given locality, populations of many small mammals show considerable fluctuation from season to season and from year to year. The abundance of a particular species also varies from one part of its range to another. For these

TABLE 3.—*Population densities of eastern chipmunks from June 14, 1949 to July 3, 1950*

DATES	AREA*	NUMBER OF ACRES TRAPPED	ANIMALS CAPTURED	ESTIMATED NUMBER PER ACRE
1949				
June 14–June 27	A and B	5.88	34	5.78
June 28–June 30	D	2.53	17	6.72
Aug. 14–Aug. 26	A and B	5.88	27	4.59
Sept. 8–Sept. 12	C	0.34	10	29.41
Oct. 1–Oct. 3	D	2.53	11	4.35
Oct. 15–Oct. 17	B	3.12	20	6.41
1950				
Mar. 28–Mar. 30	B	2.55	11	4.14
Apr. 21–Apr. 23	A	1.01	13	12.87
Apr. 28–Apr. 30	C	0.34	6	17.65
May 5–May 7	A	1.01	14	13.86
May 19–May 20	B	2.55	18	7.06
June 4–June 6	D	2.39	32	13.39
June 18–June 20	A and B	2.20	24	10.91
June 26–June 28	A and B	2.30	35	15.23
July 1–July 3	B	1.84	26	14.13
June 7–July 3	A and B	5.88	75	12.76

* A. North shore of Beebe Lake, western portion; B. North shore of Beebe Lake, eastern portion; C. Ravine, southeast of Beebe Lake; D. South shore of Beebe Lake, rear of Fernow Hall.

reasons the results of population studies for any one species will show a great deal of variation. Seton's (op. cit) observation of 20 to 30 chipmunks per acre is the highest ever recorded for this species, but pertains only to protected areas in the immediate vicinity of his home in Connecticut. This estimate may include animals which were attracted to the area by feeding stations. Population data have been given by Williams (1936), Bole (1939), Burt (1940), Blair (1941), Smith (*op. cit.*), Manville (*op. cit.*), and Linduska (1950) (Table 4).

The population densities on different portions of the study area during various periods of intensive trapping in 1949 and 1950 are listed in Table 3. The tabulated animals include only marked chipmunks; no allowance is made for individuals that were never captured or marked. Therefore, these figures are slightly less than the actual population. The data for 1950 are very close to the actual population figure, but in 1949 a greater number of resident animals escaped capture. The higher figures for 1950 do not necessarily indicate a larger population of chipmunks than in the previous year; the difference is due chiefly to the greater trapping efficiency of the larger traps used during the second year.

The study area was bounded by habitats unoccupied by chipmunks. The insignificant number of marked animals whose home sites were located outside of the study area was offset by a similarly small number of chipmunks living on the study area but never captured and marked.

Population densities computed from trapping records are influenced by the variable amount of activity of the animals at different seasons. The low population in March may be due in part to winter mortality, but also to the unfavorable weather conditions which restrict chipmunk movement at this season. Another low point in mid-summer (July and August) reflects a reduced amount of activity during the hottest parts of the year. Population peaks occur in June and September-October, and correspond to the appearance above ground of the young of the spring and summer litters.

There were no marked differences in population densities between the north and south shores of Beebe Lake. However, an unusual situation prevailed in a small ravine at the southeastern corner of the lake, next to the Cornell University apiary. In September, 1949, ten chipmunks were captured on this plot, one-third of an acre in size. These included two adults (male and female, probably a mated pair), three juveniles from a spring litter, and

TABLE 4.—*Summary of population and home range studies of the eastern chipmunk*

AUTHORITY	POPULATION PER ACRE	HOME RANGE IN ACRES (ADULTS ONLY)
Williams (1936)	4.00–15.00	
	Ave. 9.50	—
Bole (1939)	0.80–8.70	
	Ave. 4.80	—
Burt (1940)	0.80–3.62	1.04–2.04
	Ave. 2.21	Ave. 1.54
Blair (1941, 1942)	3.32	2.15–2.31
		Ave. 2.23
Smith (1942)	1.11–3.24	1.66–3.10
	Ave. 2.18	Ave. 2.38
Manville (1949)	0.12–0.72	0.19–0.43
	Ave. 0.42	Ave. 0.25
Linduska (1950)	Approx. 0.05–2.5	—
Present Study	4.14–15.23	0.26–0.37
	Ave. 9.68	Ave. 0.32

five young from a second or summer litter. The population density was 29.4 chipmunks per acre, equal to Seton's highest estimate. In late April, 1950, five of the ten chipmunks were retaken on the same area, and one new individual had appeared. Of the five individuals from the summer litter, only one female was recaptured. The population at this time was 17.65 per acre, a concentration which was never equalled on any other part of the study area.

Since the results of at least seven population and home range studies of the chipmunk have been published, a comparison of results appears desirable. Table 4 summarizes the data obtained by various investigators. The minimum and maximum populations and home ranges are taken from their publications; the average is merely the arithmetic mean of the maximum-minimum figures. The data on this table are not entirely comparable since the studies were not all made at the same time of year, and various types of trapping techniques were employed.

There are several explanations for the exceptionally low population figures of two previous studies. Linduska (*op. cit.*) conducted part of his trapping operations in grazed woodlots, a poor type of habitat for chipmunks. The distant spacing of his traps (one per acre) probably failed to capture the entire population. Manville (*op. cit.*) explained that his field work was carried out in a region of uninterrupted forest where the chipmunk population apparently never reaches a high level.

If the unusually high population figures for the small ravine area described above are omitted, the populations in this study are comparable to those found by Williams (*op. cit.*). The mean of the population densities for 1950 (Table 5) is 11.6 per acre, the highest population of chipmunks recorded in the literature with the exception of Seton's estimated figures.

SUMMARY

Home range, territoriality, and population densities of the eastern chipmunk *Tamias striatus lysteri* (Richardson), were studied in the environs of Beebe Lake, Ithaca, New York, from June 14, 1949 to July 15, 1950. Abundant food and excellent cover provided an ideal habitat for chipmunks. Two hundred and eighteen animals were live-trapped and marked by toe and fur clipping. Observations of marked animals supplemented trapping data. The minimum-home-range method of calculating was used, and is recommended as the most useful one when comparisons are to be made between such studies. The average size of the home range of adult males was 0.37 ± 0.05 acre; of adult females, 0.26 ± 0.03 acre; and of juveniles, 0.18 ± 0.03 acre. Broad overlapping of home ranges occurred. The majority of individuals occupy the same home range over long periods of time. The tendency to abandon a home range and move to a new area or home range site appears to be more common among males than females. The small size of home ranges in this study apparently results from a combination of favorable habitat and high population densities. Antagonism between individuals of the same and opposite sex indicates that the chipmunk displays territoriality, although this behavior may not be as conspicuous nor as highly developed as in some other mammals. Population densities varied from 4.14 to 15.23 chipmunks per acre, but one instance is recorded where ten chipmunks inhabited a restricted area one-third of an acre in size. A comparison is made of the various home range and population studies of the chipmunk in the northern United States.

Acknowledgments.—I wish to express my gratitude to Dr. William J. Hamilton, Jr. for the advice, suggestions, and criticism which he proffered throughout the course of this study, and for a critical reading of the manuscript. This is a part of a doctoral dissertation submitted to the faculty of the Graduate School of Cornell University, Ithaca, New York.

LITERATURE CITED

Allen, D. L. 1943. Michigan fox squirrel management. Michigan Dept. Conserv., Game Div. Publ. no. 100: 1–404.

Allen, Elsa G. 1938. The habits and life history of the eastern chipmunk, *Tamias striatus lysteri*. Bul. N. Y. State Mus., no. 314: 1–122.

Blair, W. F. 1940. A study of prairie deer-mouse populations in southern Michigan. Amer. Midl. Nat., 24: 273–305.

———. 1941. The small mammal population of a hardwood forest in northern Michigan. Contr. Lab. Vert. Genetics, Univ. Michigan, no. 17: 1–10.

———. 1942. Size of home range and notes on the life history of the woodland deer-mouse and eastern chipmunk in northern Michigan. Jour. Mamm., 23: 27–36.

Bole, B. P., Jr. 1939. The quadrat method of studying small mammal populations. Sci. Publ. Cleveland Mus. Nat. Hist., 5(4): 15–77.

BURT, W. H. 1940. Territorial behavior and populations of some small mammals in southern Michigan. Misc. Publ. Mus. Zool., Univ. Michigan, no. 45: 1–58.

———. 1943. Territoriality and home range concepts as applied to mammals. Jour. Mamm., 24: 346–352.

———. 1949. Territoriality. Jour. Mamm., 30: 25–27.

CLARKE, C. H. D. 1939. Some notes on hoarding and territorial behaviour of the red squirrel *Sciurus hudsonicus* (Erxleben). Canadian Field Nat., 53: 42–43.

EVANS, F. C. 1951. Notes on a population of the striped ground squirrel (*Citellus tridecemlineatus*) in an abandoned field in southeastern Michigan. Jour. Mamm., 32: 437–449.

FRALEIGH, LUCY B. 1929. The habits of mammals at an Adirondack camp. Handbook New York State Mus., no. 8: 119–169.

GORDON, K. 1936. Territorial behavior and social dominance among Sciuridae. Jour. Mamm., 17: 171–172.

HARPER, F. 1929. Notes on mammals of the Adirondacks. Handbook New York State Mus., no. 8: 51–118.

HAYNE, D. W. 1949. Calculation of size of home range. Jour. Mamm., 30: 1–18.

———. 1950. Apparent home range of *Microtus* in relation to distance between traps. Jour. Mamm., 31: 26–39.

KLUGH, A. B. 1927. Ecology of the red squirrel. Jour. Mamm., 8: 1–32.

LINDUSKA, J. P. 1950. Ecology and land-use relationships of small mammals on a Michigan farm. Game Div., Dept. Cons., Lansing, Michigan, 144 p.

MANVILLE, R. H. 1949. A study of small mammal populations in northern Michigan. Misc. Publ. Mus. Zool., Univ. Michigan, no. 73: 1–83.

MOHR, C. O. 1943. A comparison of North American small-mammal censuses. Amer. Midl. Nat., 29: 545–587.

———. 1947. Table of equivalent populations of North American small mammals. Amer. Midl. Nat., 37: 223–249.

RHOADS, S. N. 1903. The mammals of Pennsylvania and New Jersey. Philadelphia, Privately publ., 1–266.

SETON, E. T. 1929. Lives of game animals. Doubleday, Doran & Co., Inc., vol. 4, pt. 1: 184–215.

SMITH, R. A. 1942. The biology of a small mammal community in a central New York woodlot. (Doctorate thesis, Cornell University, 218 p.)

WILLIAMS, A. B. 1936. The composition and dynamics of a beech-maple climax community. Ecol. Monogr., 6: 318–408.

Department of Zoology, The Florida State University, Tallahassee. *Received August 15, 1952.*

BEAVER ECOLOGY IN WESTERN MONTANA WITH SPECIAL REFERENCE TO MOVEMENTS

By Joseph E. Townsend

Beaver (*Castor canadensis*) ecology with reference to movements was studied in the Seeley Lake area of Missoula County, Montana. Data were obtained by live-trapping, individually marking, and recapturing beavers in the summer of 1949, 1950, and 1951 on a 160 acre area and from 15 beavers trapped (14 pelted, 1 released) in this area during the 1952 commercial trapping period. Thirty-six beavers were caught 62 times. Supplementary information was obtained by studying and recording beaver sign throughout the study area.

The writer thanks the following for aid in the study: Dr. Don C. Quimby, who directed the study, for advice in the field and in the manuscript preparation; Mr. Adrian Hess for help in statistical analysis; Dr. W. E. Booth for assistance in plant identification; my father and mother, Mr. and Mrs. George B. Townsend, for permission to conduct the study on their property; Mr. Robert Christianson and especially my brother, George, for aid in collecting material and data from winter trapping; the Montana State Fish and Game Department for permission to conduct the study and for the use of live-traps; my wife, Marjorie, for aid in typing and in preparation of figures and tables. This is a contribution from Montana State College, Agriculture Experiment Station, Project No. MS844, Paper No. 282, Journal Series.

Description of area.—The study area (Fig. 1) is located within the river meander plain of the Clearwater River valley, 3½ miles upstream from Seeley Lake. The valley is bounded to the west by the Mission Mountain Range and to the east by the Swan Range. Its width at the study area is about two miles. The meander plain of the river, 20 to 30 feet below the valley floor, is one-half to one mile wide.

Excluding the meander plain, the valley is heavily timbered with western larch (*Larix occidentalis*) on the lower slopes, and ponderosa pine (*Pinus ponderosa*), douglas fir (*Pseudotsuga taxifolia*), and Engelmann spruce (*Picea engelmanni*) on the upper slopes. Stands of lodgepole pine (*Pinus contorta*), are found at various elevations. The meander plain is characterized by willow (*Salix* spp.) and red osier dogwood (*Cornus stolinifera*), with Engelmann spruce along the higher stream banks and lodgepole pine on extensions of dry land.

The study area includes a one mile segment of the Clearwater River, a spring creek tributary, and the lower parts of two other tributaries. The river (Fig. 1) enters the area from the northwest and cuts diagonally across to the southeast corner. It is characterized by low banks (6–12 inches in height is common), a gravel bottom and low turbidity. Width varies from ten to 50 feet, depth from a few inches to about four feet. Volume flow in July and August (floating chip and watch method) was from 15 to 20 cubic feet per second; high spring water considerably increases this flow and a reduction is apparent in late summer.

Findell Creek, a shallow stream two to six feet wide, enters the river from the northeast. The West Fork of the Clearwater River, a larger stream, enters from

the west. Its channel has been much influenced by beaver activity. Consequently, it joins the river through a network of channels and beaver runs. A small stream

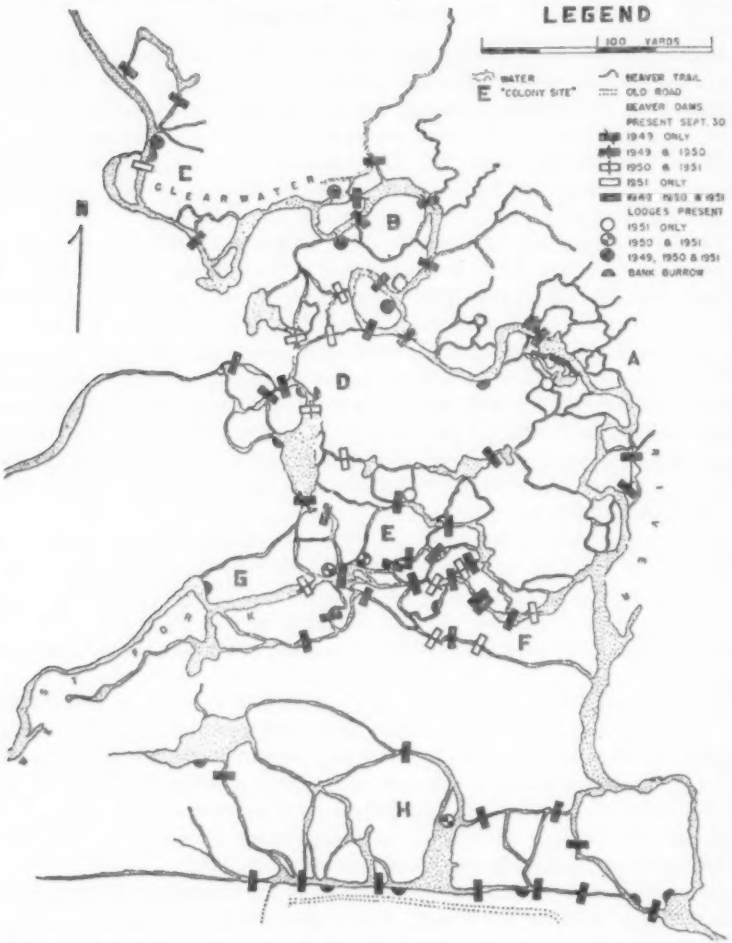

FIG. 1.—Map of study area, showing water, beaver structures, and colony sites (site I, upper West Fork, is excluded).

originating from a spring in the southern end of the area enters the river at its point of exit from the study area.

Principal vegetative types are: coniferous forest, woody shrub, emergent aquatics, and submerged and floating aquatics. A grove of quaking aspen (*Populus tremuloides*) is present just south of the area.

The coniferous forest consists of Engelmann spruce, a few scattered western larch, and three stands of lodgepole pine. The spruce is restricted to the higher stream banks of two areas: (1) A stand of old mature trees along the lower section of the river with an extension up the main channel of the West Fork, and (2) a scattered stand of young trees, six to eight feet in height, occurring as a low canopy under the lodgepole extension from the west into the middle of the area (Fig. 1). The western larch occurs as a very scattered stand of old, single trees. Many are dead. No larch reproduction is evident. The lodgepole pine occurs: (1) on an extension of dry land (previously mentioned) from the west into the middle of the study area, (2) in a heavy growth between the West Fork and the southern boundary and (3) a small stand near the entry of Findell Creek.

Representative plants under the mature spruce were common juniper (*Juniperus communis*), bearberry honeysuckle (*Lonicera involucrata*), mountain snowberry (*Symphoricarpos albus*), Saskatoon service berry (*Amelanchier alnifolia*), Hudson Bay currant (*Ribes hudsonianum*), alder buckthorn (*Rhamnus alnifolia*), American strawberry (*Fragaria vesca*), field mint (*Mentha arvensis*), bunchberry dogwood (*Cornus canadensis*), and starry solomonplume (*Smilacina stellata*). Those under the pine include bearberry honeysuckle, mountain snowberry, common juniper, American strawberry, and common beargrass (*Xerophyllum tenax*).

The woody shrubs, in order of abundance, were willow, red-osier dogwood, and thin-leaf alder (*Alnus tenuifolia*). This type covered the non-wooded land area with the exception of extremely wet or inundated parts. In the drier localities various plants were found with the woody shrubs. Representative are: alder buckthorn, field mint, common cow parsnip (*Heracleum maximum*), bluejoint reedgrass (*Calamagrostis canadensis*), bearded wheatgrass (*Agropyron subsecundum*) and sheep sorrel (*Rumex acetosella*).

The most extensive areas of emergent aquatics were in the region of the West Fork, with its network of canals and beaver runs. Beaked sedge (*Carex rostrata*) and green bulrush (*Scirpus atrovirens*) were dominant. Emergent plants found in the river were slender bur-reed (*Sparganium multipedunculatum*), spike-sedge (*Eleocharis macrostachya*), oval-head sedge (*Carex festivella*), beaked sedge, and short-awn foxtail (*Alopecurus aequalis*). In the spring creek along the south border of the study area, rocky mountain rush (*Juncus saximontanus*) and oval-head sedge were found bordering areas of beaked sedge and green bulrush.

Submerged and floating aquatics collected were: river—American brooklime (*Veronica americana*), marestail (*Hippuris vulgaris*), common waterstarwort (*Callitriche palustris*), stiff watercrowfoot (*Ranunculus longirostris*), and water-crowfoot (*Ranunculus trichophyllus*); West Fork—Illinois pondweed (*Potamogeton illinoensis*) and common waterstarwort. Green algae (*Mougeotia* sp.) were very common in the river, and blue-green algae (*Cylindrospermum* sp.) were found scattered throughout the area. Plant nomenclature for monocotyledons follow W. E. Booth's *Flora of Montana*, Part I, and for dicotyledons, Gray's *Manual of Botany* (Ed. 8).

The area has not been extensively farmed; the last agricultural usage was in 1940, when a few head of stock were pastured. With the exception of commercial

trapping in the years 1942, 1944 and 1947, and trapping during the study, neither the beaver nor their activities have been legally subjected to human interference for at least 30 years.

METHODS AND RESULTS

Mapping.—A United States Forest Service aerial photograph and a ground survey of the waterways were used to map the area. All beaver structures were designated on the map and subsequent changes during the study were recorded (Fig. 1). The structures were generally concentrated in nine areas or "Colony sites" assigned letters A–I.

Trapping.—Live-trapping was accomplished with both Bailey and Hancock beaver live-traps. Traps were set in localities of apparent beaver activity, and their locations usually changed if a beaver was not caught within three nights. Three different-type trap sets were used: bait, runway and dam. The bait set consisted of scent (beaver castoreum) and/or food (fresh aspen or willow) with the trap set to catch an investigating beaver. The runway set was in a waterway, such as a canal, with sticks often placed in a "V" to guide the animal directly over the trap. A dam set was made by breaking a hole in a dam and placing a trap in its upstream opening.

TABLE 1.—*Analysis of various types of live-trap sets; 1949, 50, 51*

MONTH	BAIT			RUNWAY			DAM			ALL SETS		
	TN	C	TN/C	TN	C	TN/C	TN	C	TN/C	TN	C	TN/C
June*	42	1	42.0	14	0	—	9	0	—	65	1	65.0
July	86	6	14.3	21	2	10.5	33	3	11.0	140	11	12.7
August	100	6	16.7	23	3	7.7	65	8	8.1	188	17	11.1
September	118	7	16.9	20	3	9.7	50	8	6.3	197	18	10.9
Total trapping periods	346	20	17.3	87	8	10.9	157	19	8.3	590	47	12.6

* No trapping until after June 15 in any year.

Symbols: TN, trap-nights; C, beaver catches; TN/C, trap-nights per beaver catch.

Thirty-one beavers were live-trapped 47 times in 590 trap-nights (one trap set one night), an average of 12.6 per beaver (Table 1). The data for the entire trapping period show: (1) beavers were captured more efficiently in dam sets, requiring 8.3 trap-nights per animal, in comparison to 10.9 and 17.3 for runway and bait sets respectively, and (2) trapping efficiency generally increased as the season progressed. Analysis, by month, reveals that runway sets were the most efficient trapping method in July and August, and dam sets in September. A bait set accounted for the only beaver caught in June; this method reached its highest efficiency in July. The relationship of trapping efficiency to beaver activity will be discussed later.

In March and April of 1952, 15 beavers were commercially trapped (14 pelted, 1 released) from the study area. Ten had been previously live-trapped.

Marking.—Six beavers were marked in 1949 by punching holes in the webs of the hind feet with a $\frac{3}{16}$-inch leather punch (method and code system described by Aldous, 1940). An additional beaver, accidentally released before examination, was identified by a large distinctive notch in the tail. In 1950, nine were web-punched. Three others, when caught, bore marks of unknown origin sufficient for identification without additional marking; each beaver had at least three identifiable marks, such as a notched tail, notched ear, split web(s), missing toe(s) or feet, etc. In 1951, eight were web-punched. Seven of these were also marked by punching a hole in the tail. Three others bore marks of unknown origin as described above; two of these were further marked by tail-punching. In the three years, the identity of 30 beavers was thus established in the area.

No recaptures were made in 1949, but the notched-tail beaver (caught in August) was found dead in October. In 1950, one animal marked September 10, 1950 was recaptured September 17. In 1951, two beavers marked in 1949 were recaptured; one of them three times, the other once. Seven, originally caught in 1950 (four web-punched and three bearing marks of unknown origin) were recaptured in 1951; three twice, the others once. One, web- and tail-punched in July, 1951, was recaptured a month later. At the time of recapture in 1951 all web-punched beavers, with one exception, were tail-punched. The ten marked animals caught in the 1952 pelting operation included five of the 1951 recaptures (originally trapped: one, 1949; three, 1950; one, 1951). Recaptured for the first time in 1952 were: one web-punched in 1950, one web-punched in 1951, and two web- and tail-punched in 1951. Another, whose hind feet were torn by the trap, could not be identified with certainty. It had at least one punch mark. Another possibly could have been obliterated.

These recaptures supply a basis for evaluating web-punching as a means of marking. The beaver examined seven days after web-punching apparently suffered no ill effects; the holes in the webs were distinct. After 11 months the web-punches of this animal had healed into light colored, linear scars, ⅛ inch in length, from which fine lines radiated into the surrounding web. A lump could be felt in the intercutaneous fascia. Eight months later, the only change noticeable in these same marks was a darkening in color. The web-punches of another beaver, one month after punching, were partially filled with tissue, and six months later were completely filled. This pattern of web-punches filling in and eventually healing into faint scars is evident in the histories of 11 of 12 beavers for which recapture data are available. Twenty-one recaptures, representing periods of from one week to 33½ months, were analyzed. The exception to this healing pattern was a beaver whose web-punch had been enlarged with a scissors; examination, 11, 13, and 20 months after marking, revealed a distinct hole, ¼ inch in diameter, through the web.

Aldous (*loc. cit.*) lists two disadvantages to web-punching: (1) unless the holes in the upper and lower surfaces of the web coincide, only a faint scar remains after healing, and (2) identification by inexperienced personnel is unreliable. Great care was taken to inflict the holes so that they would normally coincide. This was verified by examination of pelted beavers in 1952, eleven of 13 punched webs had the upper scar directly over the lower. It would appear that regardless of care taken in punching, web-punches made with a 3/16-inch leather punch will eventually heal into a faint scar.

The technique, although serving the purposes of this study, was not entirely satisfactory. Identification of individuals often required very careful and deliberate examination, but it is felt that all beavers were properly identified, excluding one, multilated in the 1952 pelting operation. This belief is strengthened by data obtained on supplementary marked animals. In all instances the web marks of this group were similar to those identified in beavers that were web-punched only. Furthermore, weights and body measurements of beavers identified by web marks were in every instance in agreement with the original records within the limits of normal change. In view of its shortcomings, the writer would not recommend this method of marking for a large scale study.

Tail-punching was found to be satisfactory up to 10 months, but no data are available for longer periods. The holes did not fill in completely although they did decrease in size.

Sexing.—Presence of a baculum, determined by inserting a finger in the urogenital opening (Bradt, 1938), was considered positive evidence of a male (Bradt was thus able to sex all beavers except kits). Ten males were sexed by this method. No accurate method of sexing live kits was known to the writer, but of the four live-trapped, one (male) was later examined as a two-year-old, two (male and female) were commercially trapped and examined, and one (male) was found dead in a trap. Four adult females, when first captured, were sexed on the basis of conspicuous mammary glands. Of 13 sexed as females by the absence of a baculum, two had conspicuous mammae when recaptured, two were verified by examination during the 1952 pelting operation, two were recaptured and again no baculum felt, five were not recaptured, and two were found to be erroneously sexed. A 31 pound animal sexed in 1949 as a female proved to be a male when recaptured in 1951. An adult

male pelted in 1952 was incorrectly sexed in 1951. In both cases a male was involved. Evidently considerable experience is necessary to reach the high degree of efficiency in establishing the presence of a baculum indicated by Bradt.

The sex of 26 of 31 was established within reasonable doubt. Five, sexed as females by the absence of a baculum, were not verified by recapture. The possibility of one or more of these being erroneously sexed is recognized.

Ageing.—Beavers were weighed and measured (total length, length and width of scaley part of tail, and hind foot) to determine whether the measurements fell into distinct and separate categories. Frequency distributions suggested that these measurements were not taken from a single group. Inspection of the frequency distributions and field experience indicated that weight was the best criterion for establishing separate categories. To substantiate the hypothesis that weight frequency (Fig. 2) represented more than one group, Chi-square for testing "goodness of fit" of the normal frequency curve was computed. The large value of Chi-square (13.47 with df = 2) would occur as the result of chance alone in less than one time in 100, strongly suggesting that more than one group had been weighed.

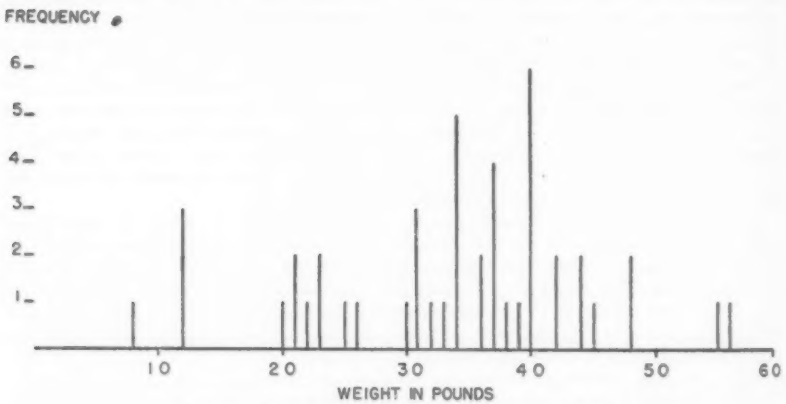

FIG. 2.—Frequency distribution of beaver weights

Further examination of the weight frequency distribution shows an apparent grouping of weights into three categories: (1) 8–12 pounds, (2) 20–26 pounds, and (3) 30 pounds and over. These apparent groups were tested for equal variances ("F" test, Dixon and Massey, 1951) and the hypothesis rejected. The three were then tested for equal means (variances not equal, "t" test, Dixon and Massey, 1951). The hypothesis of equal means was rejected at the 1 per cent level. The means were from different populations.

The beavers, whose weights fell into group 1, were classified in the field as kits on the basis of their small size and immaturity. The work of Bradt (1939) substantiates this classification. He gives the weights by months of four beaver kits for the first year of life. The lowest weight, in August, was 6.8 pounds and the highest, in September, was 13 pounds. At the end of their first year, Bradt's kits weighed 20.5–26.3 pounds. These weights agree with those of the second group. Further evidence that the second group of weights was obtained from year-old beavers is presented by the trapping records. Beaver No. 4 was caught as a kit on August 25, 1949, weight 12 pounds; on September 11, 1951, 34 pounds. No. 9 was caught July 24, 1950, weight 21 pounds; August 12, 1951, 33 pounds. No. 11 weighed 21 pounds on August 11, 1950 and 30 pounds one year later, July 26, 1951. The latter animal was weighed again September 22, 1951, weight 36 pounds. Evidently the second group of weights represented a yearling class.

By elimination of the kits and yearlings and by reference to beavers 4, 9 and 11 (above), the weights of the third group were thought to represent 2-year-olds and older.

Hammond (1943) gives weights of 118 beaver caught in the Lower Souris National Wildlife Refuge during February, March and April 1942. The weights of his suggested age groups (first year, second year, and adult beaver), generally agree with those above if allowance is made for seasonal differences.

Since two-year-old beavers are of particular significance in beaver emigration (Bradt, 1938), it was desirable to separate this group from the adult population. On the basis that beavers first breed at 2½ years (Bradt, 1938), all females showing evidence of suckling young (conspicuous mammae) were judged to be three years old or older, thus eliminating them from the two-year-old group.

A frequency distribution of the third group of weights, exclusive of suckled females (Fig. 3), suggested two groups: 30–36 pounds and 37 pounds and over. The two groups were tested for equal variances ("F" test), and this hypothesis rejected. The two were then tested for equal means (variances not equal, "t" test). The rejection of the latter hypothesis at

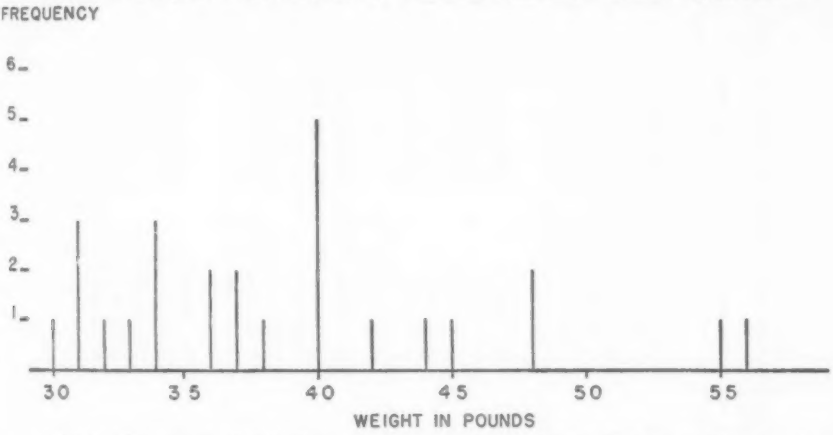

FIG. 3.—Frequency distribution of beaver weights exclusive of kits, yearlings, and suckled females.

the 5 per cent level suggested that these two groups of weights were obtained from different populations. The records of beavers 4, 9 and 11 (previously discussed) suggest that the lower weight group represented two-year-old beavers. The upper weight group obviously represents an adult class. The record of beaver No. 1 supports this conclusion (June 26, 1949, 31 pounds, two-year-old; August and September 1951, 44–48 pounds, four-year-old).

Confidence limits, at the 99 per cent level, established for the means of the weights for kits, yearlings, two-year-olds and adults (females with kits excluded) were 5.16–16.84, 20.4–25.02, 30.73–34.87,, and 38.98–48.62, respectively. Classification of a few animals whose weights were near the border-line between two-year-olds and adults was verified by reference to body measurements. Only one exception to weight classification was noted. Both the 1950 and 1951 weights of beaver No. 12 fell well within the range of the two-year class (31 and 34 pounds respectively) but 1950 body measurements indicated a two-year-old, and 1951 measurements, an adult. Ulcerous sores on the body of this animal were noted in 1950.

Body measurements of kits, yearlings, two-year-olds, and adults, as determined by weight, sexual activity and established-age animals, are given for the summer months in Table 2.

TABLE 2.—*Summer weights, in pounds, and measurements, in inches, of various age classes of beavers*

	NO. KITS	NO. YEARLINGS	NO. TWO-YEARS	NO. FEMALES WITH KITS	NO. ADULTS WITHOUT KITS
July					
Weight	0	2 21.5(21–22)	2 30.5(30–31)	3 38.7(37–40)	5 42.6(37–56)
Hind foot	0	2 5.75(5.5–6.0)	1 6.25	3 6.75(6.5–7.0)	5 6.7(6.3–7.0)
Total length	0	2 31.5(30–33)	1 36.0	3 38.0(37–40)	5 39.8(38–43)
Tail width	0	2 3.4(3.25–3.5)	1 4.0	3 4.9(4.5–5.1)	5 5.0(4.5–5.5)
Tail length	0	1 9.0	1 8.5	3 10.3(10–11)	4 10.5(9.5–11.0)
August					
Weight	2 10(8–12)	3 21.3(20–23)	3 34.3(33–36)	4 36.8(34–42)	4 40.5(34–48)*
Hind foot	2 4.6(4.5–4.9)	3 6.0(6.0)	3 6.6(6.5–6.75)	4 6.7(6.5–6.75)	4 7.0(6.75–7.5)
Total length	2 24.7(24.5–25)	3 33.0(31–35)	2 37.5(37–38)	4 38.5(37–41)	4 40.7(37–45)
Tail width	2 2.4(2.3–2.5)	3 4.4(4.0–4.75)	3 4.4(4.0–4.75)	4 4.8(4.5–5.75)	4 4.7(4.25–5.25)
Tail length	1 6.0	1 8.0	3 10.1(10–10.3)	4 10.6(10–10.75)	3 10.5(10–11)
September					
Weight	2 12.0(12)	3 24.7(23–26)	5 32.8(31–36)	1 44.0	7 44.1(37–55)
Hind foot	2 4.8(4.5–5.0)	3 6.1(6.0–6.25)	5 6.45(6.25–6.5)	1 6.5	7 6.9(6.75–7.0)
Total length	2 29.5(25–34)	3 32(31–33)	5 37.0(36–38)	1 40.0	7 40.7(39–43)
Tail width	2 2.5(2.5)	3 4.0(3.75–4.3)	5 4.65(4.0–4.75)	1 4.75	7 5.2(5.0–5.5)
Tail length	2 7.3(7.0–7.5)	3 9.1(8.75–9.5)	5 9.8(9.5–10.5)	1 11.0	7 10.6(10.0–11.3)
Summer					
Weight	4 11.0(8–12)	8 22.6(20–26)	10 32.8(30–36)	8 38.4(34–44)	16 42.8(34–56)*
Hind foot	4 4.7(4.5–5.0)	8 5.9(5.5–6.25)	9 6.5(6.25–6.8)	8 6.7(6.5–7.0)	16 6.8(6.3–7.5)
Total length	4 27.0(24.5–34)	8 32.3(30–35)	8 37.0(36–38)	8 38.5(37–41)	16 40.4(37–45)
Tail width	4 2.4(2.3–2.5)	8 3.7(3.0–4.25)	9 4.5(4.0–5.0)	8 4.8(4.5–5.75)	16 5.0(4.25–5.5)
Tail length	3 6.8(6.0–7.5)	6 8.9(8.0–9.5)	8 9.7(8.5–10.5)	8 10.5(10–11)	14 10.6(9.5–11.25)

* Includes Beaver 12 (see text).

BEAVER ACTIVITIES

From the middle of June to the end of September, 1950 and 1951, the area was covered at least twice a week and notes on beaver structures, food cuttings, and scats were recorded. In 1949 fewer data were taken.

Structures.—Beaver structures were typically dams, lodges, stockpiles, canals, burrows, and scent mounds. Dams varied in size from small canal dams, two feet long and a few inches high (height measured from top of dam to stream bed) to larger stream dams up to 42 feet long and five feet high.

Lodges were similar in size, shape and construction; about three to four feet high, ten feet wide, and 18 feet long. All were on dry land within ten feet of water. Eight of ten were concealed by vegetation.

TABLE 3.—*Time of dam building activity in 1949, 1950, and 1951*

	1949		1950		1951		TOTAL	
	DS	DF	DS	DF	DS	DF	DS	DF
July								
1st half	0	0	0	0	0	0	0	0
2nd half	1	0	0	0	2	0	3	0
August								
1st half	3	4	4	3	2	2	9	9
2nd half	4	3	14	4	6	3	24	10
September								
1st half	3	4	2	13	3	5	8	22
2nd half	1	1	0	0	2	5	3	6

Symbols: DS, dams started; DF, dams finished.

TABLE 4.—*Time of scent mound activity in 1949, 1950, and 1951, as indicated by number of scent mounds constructed*

	JUNE	JULY		AUGUST		SEPTEMBER
	2nd half	1st half	2nd half	1st half	2nd half	1st half
1949	0	3	5	1		
1950	2	6	5	1	1	
1951	2	11	10	4	3	2
Total	4	20	20	6	4	2

Stockpiles, usually willow, were found near lodges in water three to five feet deep. Canals ranged in size from two to ten feet wide, and a few yards to 120 yards long. No bank burrows were excavated, but a number were found. Scent mounds were typically a pat of mud. Three over two feet high were found (result of over two years activity).

Seasonal dam building activity is summarized in Table 3. Maintenance on dams not damaged by spring high water was noted throughout the summer, but new construction and major repair were concentrated in late August and early September. Few dams were started in September, but maintenance and improvement, as suggested by the high efficiency of dam trap-sets at this time (Table 1), was an important activity.

Table 4 shows seasonal scent mound activity. Here, as above, a correlation is found between trapping efficiency and activity. The peak period for scent mound construction, July, agrees with the most efficient time for bait sets (Table 1).

Five lodges were built during the study; all late in the season (found the following summer). No stockpiles were known to have been accumulated before the last week of September. Two canals were constructed, both in the first half of August.

Food Cuttings.—Food cuttings of willow, dogwood, alder and aspen (aspen in colony site H only) were found throughout the summer. Rhizomes of beaked sedge were utilized during June, July, and August. Pondweed and waterstarwort were heavily utilized in colony sites D and E during August (based on observations of feeding beaver and plant cuttings).

TABLE 5.—*Population dynamics data, Summer, 1949*

COLONY SITES	A	B	C	D	E	F	G	H	I
Catches			none	none			none	none	none
Adults	8/27–5M*	8/20–6aS*							
		10/?–6aS							
2 yrs.	none	none			8/14–2M	6/26–1M			
1 yr.	none	8/23–3F							
		8/27–6M							
Kits	none	8/25-4M							
Structures									
Dams**	6	8	3	3	7	6	6	12	?
Dams built	1	4	1	none	none	6	none	none	?
Lodges	1	3	1	none	none	none	none	none	none
Lodges in use	1	2	1						
Stockpiles previous year	1	1	?	none	1	none	none	none	?
Food cutting***									
June	?	?	none	?	L	L	L	H	?
July	L	L	none	?	L	L	L	L	none
August	L	M	L	none	L	H	M	L	none
September	none	H	L	?	M	M	L	M	?
Scats****									
June	?	?	?	?	M	none	?	LM	?
July	L	LM	none	?	M	M	M	M	none
August	L	LMS	none	none	MS	M	none	M	none
September	none	LMS	M	?	MS	M	none	LM	?

* 8/27/5M (Caught Aug. 27—Beaver No. 5, Male); 8/20 6aS (Aug. 20—No. 6a, Suckling female).

** Dams present Sept. 30.

*** L, Light; M, Medium; H, Heavy.

**** LMS = Large, Medium, and Small (see text).

Mint and cow parsnip were eaten to a minor extent. One instance of young lodgepole utilization in September (bark completely eaten off) and two of young Engelmann spruce in July were noted. Cuttings were occasionally taken from the few common juniper in colony site F.

Willow and red osier dogwood were the most heavily utilized food plants, possibly due to availability. Preference for aspen (Bradt, 1938, Aldous, 1938, Soper, 1937, and many others) was demonstrated in colony site H, where it was used almost exclusively despite the presence of willow and dogwood. Aquatics, where available, were important during August.

TABLE 6.—*Population dynamics data, Summer, 1950*

COLONY SITES	A	B	C	D	E	F	G	H	I
Catches			none	none					none
Adults	9/17–15F	none			none	7/20–8S	none	7/19–7F 9/13–14F	
2 yrs.	none	9/23–17F			none	none	9/10–12F 9/17–12F		
1 yr.	none	9/22–16F 9/25–18M			7/24–9F 7/26–10F	none	8/11–11M		
Kits	none	none			none	none	9/10–13M		
Structures									
Dams	5	6	3	8	8	10	6	12	1
Dams built	none	2	1	5	1	9	1	none	1
Lodges	1	3	1	none	none	none	2	1	none
Lodges in use	none	1	1		none		1	1	
Stockpiles previous yr.	none	1	1	none	1	none	1	none	?
Food cutting									
June	L	L	none	?	L	L	none	H	?
July	none	none	none	M	L	M	L	L	none
August	none	L	L	M	M	L	M	L	none
September	M	M	M	H	H	L	M	H	M
Scats									
June	none	none	L	none	M	M	none	M	?
July	none	none	none	M	M	M	none	M	none
August	L	M	L	LM	M	MS	MS	none	none
September	L	M	L	LM	M	MS	MS	L	?

TABLE 7.—*Population dynamics data, Summer, 1951*

COLONY SITES	A	B	C	D	E	F	G	H	I
Catches									
Adults	8/27–25S	7/17–19M 7/21–20F 9/10–1M 9/16–1M	8/25–20F	8/9–1M 8/16–7S 9/13–27M	7/17–8S 8/12–12F 8/29–8S	7/11–15S 7/25–14F 9/25–31M	7/24–21M	8/17–7S	9/21–29S
2 yrs.	8/9–23M	none	9/22–30F	8/12–9F 9/11–4M	9/22–11M	none	7/26–11M	none	none
1 yr.	none	none	none	none	none	none	9/16–28M	none	none
Kits	none	none	none	none	none	8/19–24M	none	9/8–26F	none
Structures									
Dams	5	4	4	8	8	10	6	12	1
Dams built	none	none	2	3	none	8	1	none	1
Lodges	2	3	1	none	1	none	2	1	none
Lodges in use	1	none	1	none	1	none	1?	1	none
Stockpiles previous yr.	1	1	1	1	1	none	1	none	?
Food cutting									
June	none	L	none	L	M	none	none	H	L
July	M	M	none	M	M	L	M	L	L
August	M	L	M	H	L	M	L	L	M
September	L	L	M	M	M	M	M	L	M
Scats									
June	none	L	none	LM	LM	M	none	LM	L
July	L	L	none	LM	LM	LM	M	M	L
August	LS	L	L	LMS	LMS	MS	M	MS	LMS
September	L	L	LM	LMS	LMS	LM	M	MS	LMS

Bradt (1938) has suggested the importance of aquatic vegetation in the summer months and Tevis (1950) recorded heavy utilization.

Scats.—Scats were of considerable importance in determining beaver presence. Color was a bright, greenish-brown. Three different sizes were recognized (small, one-half to three-fourths inch; medium, one to two inches; and large, over two inches in diameter), and were thought to be generally associated with different age classes. The possibility of an adult dropping a small scat was recognized, but field observations and the trapping record show that kits were active in areas where small scats were found (Tables 5, 6, and 7). Observations of droppings in quiet water in six localities indicated that the bright greenish color was lost within two to three days, deterioration of form started in four to seven days, and complete deterioration occurred between ten and fourteen days. Droppings were always found in the water.

POPULATION DYNAMICS

Beaver populations and movement during the term of the study will be presented by colony site on the basis of trapping data and activities as summarized in Tables 5, 6, and 7. The reader is referred to Figure 1 for location and structures of the colony sites.

Colony Site A.—An adult male was caught on site A, August 27, 1949. Activity data suggested no more than one beaver occupied the site until September when abandonment evidently took place. A stockpile of the previous winter suggested the site was inhabited at that time, possibly by the same beaver.

In 1950, the lack of a previous winter's stockpile suggested the desertion noted in 1949 continued throughout the winter. Cuttings were present in June and September in the southern part, and in the western part in September only. Large scats were observed in the western part in August and September. A non-breeding adult female was caught in the southern part September 17, 1950. Neither reconstruction of the river dam, destroyed by high spring water, nor use of the lodge was noted. This and her subsequent record suggested she was a "transient". The 1951 records suggest that the activity in the western part was associated with a different beaver.

In 1951 a suckled female (No. 25) was caught in the western part of the area August 27, 1951, and a two-year-old male in the southern end August 9, 1951. The western part contained a new lodge and a stockpile; both probably originated in the fall of 1950. The lodge was occupied and both large and small scats (indicating kits) were found nearby. The evidence suggests that the suckled female moved in, in late summer 1950, and was possibly responsible for the activity noted in the western part at that time. The age of the male probably precludes its being the mate of the suckled female (Bradt, 1938). Its status was probably that of a "transient." The 1952 record suggests an adult male (No. 19) as the suckled female's mate at that time.

In the 1952 commercial trapping season (February 16 to April 19), the only activity in the study area during March was noted in sites A, C, and H. A and C are on the river which remained relatively open during March, and H on the spring fed tributary (Fig. 1). The West Fork areas were frozen in and covered with snow. These areas started to break up during the first week in April. Open water appeared April 10 and trapping efficiency on the river increased rapidly from this date. Before April 10, traps set in the river near the western part of site A caught an adult male (No. 19) and the suckled female of 1951 (No. 25), now pregnant. After April 10, a non-pregnant adult female (No. 12), a two-and-one-half-year-old male (No. 11) and two one-and-one-half-year-old males (Nos. 13 and 34) were caught in the southern part of the area. The evidence suggests that the adult male (No. 19) and the pregnant female were a resident pair, the others, "transients" (probaby from West Fork sites E and G).

Colony Site B.—In 1949, a typical colony (according to Bradt, 1938, and Cook, 1943) was present. Evening observations in late August and September showed a colony composition of two adults, three yearlings, and three or four kits. A suckled female (No. 6a), two yearlings and a male kit (No. 4) were captured. The start of a stockpile among the rem-

nants of the previous winter's storage was noted. Two lodges were occupied and four river dams were built and maintained. The presence of yearlings suggested this colony had been active since late summer, 1947, or longer. The suckled female was found dead in late October.

In 1950, a two-year-old female and two yearlings were caught in September. They had not been previously captured. Neither kits nor adults were recognized during evening observations. No scat evidence of kits or large beavers was found. One lodge was inhabited, and only two of the river dams destroyed by high spring water were reconstructed. Possibly the death of the adult female in October, 1949, caused a break up in colony structure. Evidence suggested that the 1950 yearlings were 1949 kits of this area. Site E was apparently the only other site in 1949 with kits (Table 5, scats), and yearlings trapped in that site in 1950 suggested no yearling movement from that site (possibility of kit survival without the maternal parent is shown by the trapping record of No. 4). The two-year-old female was possibly a yearling member of the 1949 colony. Indications of a stockpile accumulation in late September, confirmed by the presence of a previous winter's storage in 1951, suggested these three remained during the winter. They were not recaptured in the study area.

No dams were reconstructed or lodges occupied during the summer of 1951. The area remained unchanged in April, 1952. Evidently no resident beavers were present. In July, 1951, an adult male (No. 19) and an adult nonbreeding female (No. 20) were trapped in the southern end of B (Fig. 1). The male moved from southern B to the western part of A, a distance of approximately 0.1 river-miles, between July, 1951, and April, 1952. As previously mentioned he was probably the mate of the breeding female (No. 25) in A. The adult non-breeding female moved upstream to site C, a move of 0.2 river-miles, between July 21 and August 25. She was commercially trapped at the latter site April 8, 1952. An adult male (No. 1) was caught in southern B September 10, and in northern B September 16, 1951. His 1951 record shows an upstream movement toward site C, where he was commercially trapped March, 1952. Apparently he and the adult non-breeding female (No. 20) were a resident pair of site C in March 1952.

During the 1952 commercial trapping operation two two-and-one-half-year-olds were caught in the second week of April. Lack of resident evidence (previously discussed) and time of capture suggested these two were "transients."

Colony Site C.—In 1949, a river dam was built. The lodge and burrow showed signs of use in August and September. Medium scats and light food cutting were noted in late summer. Remains of previous winter's storage in 1950 suggested the 1949 population remained through the winter. It is doubtful if this population contained a resident, breeding pair, because no small scats were found in 1950.

In 1950 the river dam, destroyed by high spring water, was reconstructed and the lodge and burrow were used. Large scats suggested the presence of an adult, or adults. Food cuttings were present in August and September. Stockpile evidence of 1951 indicated 1950–51 winter residence, but scat data suggested no breeding pair.

In 1951, two river dams were constructed. The lodge and burrow were used. Food cuttings and large scats were recorded in August and September. Medium scats were found in September only. An adult non-breeding female (No. 20), previously trapped in B, was captured in August and a two-year-old female in September. Scat data, direct observation (entered lodge when released from trap), and successful trap-set (dam set) suggested the two-year-old was at that time sharing the site and possibly the dam work with the adult female.

The above non-breeding adult female (No. 20) was commercially trapped April 8, 1952, in a pregnant state. The adult male (No. 1), captured twice in B during 1951, was pelted March 9, 1952. Winter residents were present at this time (March–April, 1952) as evidenced by scats and a partially used stockpile near the lodge. When the adult male was trapped, the river was still partly covered with ice. Beaver activity as evidenced by cuttings and tracks in snow were found only in C, A and H. The evidence suggested the adult male (No. 1) and the adult female (No. 20) as a resident, breeding pair. Another adult male was

commercially trapped one-fourth mile upstream from C in April, 1952. Date and place of capture suggested he was "unattached" at that time.

Colony Site D.—In 1949, no residents were apparent. The large pond (Fig. 1) was nearly dry, and its retaining dam was not repaired.

Considerable activity was noted in 1950. The pond-retaining dam was reconstructed, resulting in the filling of the pond. Four smaller dams were built. Scats and cuttings were noted in July, August, and September. No small scats were seen. A large beaver and a smaller one were often observed in the pond during August and September. A 1951 stockpile suggested there were 1950–51 winter residents.

In 1951, the pond-retaining dam and two others (all damaged by high spring water) were reconstructed. Three beavers were trapped below the pond-retaining dam (north or lower D): the adult male (No. 1) previously discussed under B and C, on August 9, 1951; and two two-year-olds, a female (No. 9) on August 12, 1951 and a male (No. 4) on September 11, 1951. The latter was a 1949 kit of site B. Despite heavy trapping in September, the two-year-olds were not recaptured; they had probably moved. A large beaver was often observed in lower D during August, and was once identified as the adult male (No. 1) mentioned above, by observation of tail punches. He appeared to be using a bank burrow.

Two were trapped in upper D (above or south of the pond-retaining dam). A suckled female (No. 7) was caught in a dam set August 16, 1951. The next day she was trapped in a short run leading to the aspen grove in site H. The distance was 0.23 airline miles or 0.29 water miles by the shortest route (including 25 feet overland and passage through G). An adult male was trapped in a short run September 13, 1951. Many fresh scars on the head and tail suggested recent battles. Scat evidence indicated a kit, or kits, south of the pond-retaining dam, none below it. Only medium scats were present below the dam in September. Both large and medium scats were seen above the dam throughout the summer.

The data suggested, that the suckled female (apparently maintaining a dam in D and feeding in H) was using both sites D and H. She was with kit(s) (suckled mammae). Small scats were present in D, and a kit was caught in H. The female was trapped in H in 1950. No plausible explanation is available for this "unusual behavior." The adult male trapped above the dam was using a blind run. He may have been a resident. The three beavers captured below the dam were judged to be "wandering" or "transient" animals. The evidence for the adult male (No. 1) is obvious. Age, and negative recapture record in September is suggestive for the other two.

Colony Sites E and F.—Sites E and F were so closely associated that they are discussed together. Site F includes a group of structures along the main channel, and a southern diversion of the West Fork. E includes a group of adjacent structures on West Fork diversions north of the main channel (Fig. 1). High spring waters follow the main channel and have relatively little effect on E.

In 1949 two two-year-old males were caught: one in E on August 14, and another (the much discussed No. 1) in F on June 26. Presence of a kit(s) in E was suggested by scats, and by the presence of yearlings in 1950. Six dams were built in F and none in E. Age and time of capture suggested the beaver caught in F was a "transient." Time of capture and successful trap set (dam) possibly suggested the other was maintaining a dam(s) in E at this time.

In 1950 a dam was constructed in E. Nine, damaged by high spring water, were reconstructed in F. Small scats were noted near the burrow in F (Fig. 1) in August and September. Two yearling females (No. 9 and 10) were trapped in E, July 24 and 26 respectively. A suckled female (No. 8) was caught in F, July 20. At least one yearling was observed in F. The data suggested the suckled female may have been the maternal parent of kit(s) in F and the yearlings in E, and possibly a resident of both sites.

In E in 1951, a new lodge and a previous winter's stockpile were noted. Three beavers were trapped in dam sets: the suckled female (No. 8) of 1950 on July 17 and August 29, a non-breeding adult female (No. 12) on August 12, and a two-year-old male (No. 11) September 22. Small scats indicated a kit(s) present.

In F in 1951, eight washed-out dams were reconstructed. Scent mound activity was relatively heavy. Four beavers were trapped: a suckled female (No. 15, caught as a "transient" southern A, 1950) on July 11, an adult non-breeding female on July 25, a kit (dead in trap) on August 19, and an adult male on September 25. Small scats were not found after the kit died.

The suckled female in F (No. 15) moved from southern A (1950) to F, where she was with a kit in 1951. She was evidently inhabiting at least part of the area used by the suckled female of E (No. 8) in 1950. The latter was now found as a breeding, resident female in E. The adult non-breeding female and the two-year-old male had moved from residency in G, 1950 (also early 1951 for the male), to E, where they were trapped apparently assisting in dam maintenance, 1951. The status of the adult non-breeding female in F, a very fat, crippled animal, was possibly that of a "wandering" adult. The adult male in F could have been a "wanderer," or he may have been the mate of either of the suckled females (or both ?).

Colony Site G.—In 1949 few data were taken. Cuttings were noted throughout the summer; medium scats in July.

In 1950, two new lodges were noted in the lower end (eastern); one apparently abandoned before completion. Remnants of a previous winter's stockpile were found nearby. A new dam was constructed in the West Fork above the lodges. Medium and small scats were found above the dam and near the burrow in August and September only. Three beavers were caught. A two-year-old female was captured near the burrow in the western part, September 10, and at the new dam, September 17. A male kit was caught in the same trap with the two-year-old, September 10. A yearling male was trapped in the eastern part, August 11. The relationship of these beavers is not clear, but their subsequent records suggest they remained together. The two-year-old female and the yearling male (Nos. 12 and 11) were live-trapped in E, 1951. All were commercially trapped within three days in April, 1952, in southern A. Although the evidence (Bradt, 1938) would indicate the improbability of a two-year-old with kits, the fact that the two-year-old and the kit were caught in the same trap is suggestive. Grasse and Putnam (1950) report a 23-pound female with a kit. They concluded she ". . . mated as a year old instead of waiting until the conventional age of two."

In 1951, a previous winter's stockpile suggested winter occupancy. The dam was very poorly reconstructed. A section washed out by spring water was replaced, but little subsequent maintenance was noted. Water level was little affected. No small scats were found. Three beavers were caught: an adult male, a two-year-old male (No. 11 caught in G, 1950, and in E, 1951), both near the burrow in the western part, July 24 and 26 respectively; and a yearling male in a dam set below the east lodge, September 16. The two-year-old male was evidently still a resident at that time, but he soon moved (see record). The adult male was possibly a wanderer, but he may have been a resident since 1950 (although not trapped then). The yearling was possibly one of the 1950 kits.

Colony Site H.—This group of structures is located along an abandoned country road on the south border of the study area (Fig. 1). The water table rises perceptibly in the spring, but no damage is sustained by beaver structures. A beaver trail leads across the old road into an aspen grove.

In 1949 two burrows were used, one in the western part and one in the river pool (Fig. 1). Heavy cutting was noted in June, followed by light feeding in July and August. No small scats were recorded.

In 1950 a new lodge was noted. It appeared to be used by beaver(s) in June and early July, but was occupied by a family of muskrats during August. In September no muskrats were observed, and peeled aspen cuttings near the entrance suggested beaver occupancy. Beaver feeding was heavy in June and September, light and sporadic during July and August. No small scats were found. Two adults, non-breeding females were trapped (No. 7 and 14). No previous winter's storage was found. The status of these beavers at that time is obscure. They were possibly "unattached" or "wandering."

In 1951 one of these suckled females (No. 7) was trapped August 17 (one day after capture

in D), and a female kit was caught on September 8. Small scats were found in August and September. No previous winter's storage was noted.

During the 1952 pelting operation the female kit (above) was taken. Another was caught and released. Tracks in the snow indicated an adult in the site. Most of the water was free from ice cover. In the eastern part (Lower H or river pool), a one-and-one-half-year-old male and the adult female (No. 15) of southern A, 1950, and F, 1951, now in a pregnant state, were pelted April 14 and April 8 respectively. Age and time of catch would suggest that the male was a "transient." The status of the female at this time is obscure. She may have been wandering or she may have moved her place of residence since July, 1951, and was now a resident of lower H.

Colony Site I.—No data are available for 1949. In September 1950, a dam was built and a burrow used. In 1951, the washed out dam was reconstructed. Light cutting in June and July and medium in August and September were recorded. A suckled adult female was trapped September 21. Small, medium, and large scats were present in August and September. Possibly the female was a member of a 1950–51 winter resident pair.

DISCUSSION AND CONCLUSIONS

Bradt (1938) concluded from a study of 42 colonies that "The 'typical' beaver colony consists of an individual family, including the two parents, the yearlings born the previous year, and the kits of the current year." His tabular data show eight of 42 with such a composition, nine contained a pair and kits, two a pair and yearlings, 11 (one a single female, the others with female(s) and kits or yearlings) had no male of breeding age, six a single male, and six a male and female. Evidently 34 of 42 were not "typical". Johnson (1927) based his census work on this "typical" colony, but recognized variations. Warren's (1926) observations seem to suggest many variations from this "typical" family group. If Bradt's definition of a colony—". . . a group of beavers occupying a pond or stretch of stream in common, utilizing a common food supply, and maintaining a common dam or dams. They may or may not be living in the same lodge or burrows."—is applied to the writer's data, colonies ranging from single animals to a "typical" family group (B) are found; very similar to Bradt's tabular data.

Bradt indicated "coming" two-year-olds leave or are driven out of the family in the spring before the birth of a new litter. The present data seem to corroborate this. Of eight live-trapped as yearlings, six were not recaptured, strongly suggesting movement(s) away from the study area. One was recaptured twice as a two-year-old, once in the original area (but no breeding female present) and later in a nearby area. The other was caught as a two-year-old after moving. In the 1952 commercial trapping season two unmarked coming two-year-olds were caught away from active colonies. Three marked as kits supply some circumstantial evidence as to age when movement occurs. One was commercially trapped at the original site as a coming yearling. The other two were not caught as yearlings, but both were trapped away from their original sites; one as a two-year-old, the other as a coming two-year-old.

The apparent activities of two-year-olds handled during the summer supply some evidence as to their time of "settling". Two handled in June and July (F, 1949; G, 1951) showed no signs of residency. Only one of three in August showed signs of settling (A, 1951; D, 1951; E, 1949). In September only one of five was judged to be unsettled (B, 1950; C, 1951; D, 1951; E, 1951; G, 1950).

Johnson (1927) stated—". . . males are frequently found living by themselves

at some distance from the lodge . . . ." Bradt suggested the male is driven from the lodge before the birth of the young, and lives separately until late summer. The present data would suggest adult male movement in my study area was much more extensive than that suggested by either Bradt or Johnson for their areas. Of the six mature males (three-year-olds included) trapped during the 1952 commercial season, two caught in active colonies early in March were judged residents (A and C), four caught in April away from active colonies were judged "transients" (A, B, C). No further data are available until July when Nos. 19 (B, 1951) and 21 (G, 1951) were captured in areas evidently without resident breeding females. In August Nos. 5 (A, 1949) and 1 (D, 1951) were found "unattached". In September No. 1 (B, 1951) was found moving upstream toward C where it is believed he found a mate (C, 1952). September was the first summer month in which male adults were caught in areas known to contain breeding females (D, F, 1951). This pattern of adult behavior possibly explains Bradt's ten colonies of females with kits or yearlings but no adult males, and six with single males. The fact that 19 of his colonies contained a breeding pair with kits and/or yearlings is not necessarily in disagreement with the behavior of males indicated in this study. His data were collected from April into November (Bradt, 1933). Males were found with females in September in this study.

Non-breeding adult females possibly showed a pattern of movement similar in some respects to that of the adult males. This was demonstrated by No. 20, "unattached" in July, 1951 (B), and residing in a different area in August (C). Four others were judged "wandering" or "unattached" at various times (A, 1950; F, 1951; H, 1950).

Movement of two breedings females was noted. No. 7 (D, H, 1951) moved from D to H in one day. No. 15 moved from F to lower H between 1951 and 1952.

Abandonment of various localities has been recorded on the basis of year to year observations of beaver structures by Warren (1927). Bradt recorded the movement of an entire colony for reasons of food supply. The present data show movement of a group of beavers from site G (1950) to E (1951) and from the latter to lower A (1952). No reason is apparent for the first move. The population pressure evident in E in 1951 could have possibly been a factor in the second. Gradual break up of a colony and abandonment of a site following the death of the breeding female is apparent in site B.

Territorial behavior was apparently exhibited by the inhabitants of D (1951) and A (1950 and 1951). Each site had "fringe areas" in outlying structures where beavers judged to be "wandering" or "unattached" were evidently restricted. They apparently did not use the area utilized by breeding residents. An adult male appeared to be defending the "resident area" of D in September. The fact that non-residents were not restricted by the physical make-up of the group of beaver structures constituting the so-called site appeared to be obvious. Further evidence that residents may be a restricting factor is afforded by the history of site B. The "typical" colony of 1949 began to disintegrate in 1950 and by 1951 the site was freely used by "wandering" beavers.

The fact that home range and territory in mammals are not synonymous has

been pointed out by Burt (1943). The same author also stated, "Population density . . . may influence the size of the home range and cause it to coincide more closely with the size of the territority." This statement is apparently borne out by the history of sites E and F. Actually on the basis of continuity of physical structures of these sites they appeared to be one unit, which was evidently the case in 1950. No. 8, breeding female, used both at that time, but in 1951 No. 8 was apparently restricted to E, and No. 15, breeding female, was found using F.

These data lead to the conclusion that colonies can not be limited arbitrarily by the grouping of beaver structures in this study area, where they are often continuous over wide areas.

The fact that the beaver colonies in this study area were not static seems obvious. The numerical population and sex and age composition of colonies changed seasonally and yearly. The status of an area or site was liable to change from year to year. Undoubtedly much of this was due to disturbing factors such as high spring water. Colonies were present which appeared to resemble the "typical" colony. These same colonies would not conform at other times. It appeared that a breeding female, if successful, would eventually become the maternal member of a family group consisting of kits, yearlings, and possibly, during late summer, fall, and winter, an adult male, providing there were no disrupting factors. This would constitute not the "typical", but the potentially ultimate or maximum beaver colony.

SUMMARY

A study in beaver ecology with emphasis on movement was conducted on a 160 acre area in Missoula County, Montana, during the summers of 1949, 1950, and 1951, and the winter commercial trapping season of 1952.

The area contained a one mile segment of the Clearwater River, a spring creek tributary, and the lower parts of two other tributaries.

The principal vegetative types on the area were coniferous forest, woody shrub, emergent aquatics, and submerged and floating aquatics. Woody shrub, mostly willow, was predominate.

Data were obtained from live-trapping and recapturing 31 beavers and from commercially trapping 15, ten of which were previously live-trapped. Sixty-one catches were made. Of the three types of trap sets used, bait, runway, and dam, dam sets were generally the most efficient, but were surpassed by runway sets in July and August.

Beavers were marked by the Aldous web-punch method, which was found to be adequate for the purposes of this study, but the results would not justify its use for large scale studies.

Sexing of all age classes but kits was accomplished by establishing the presence of a baculum for males, and conspicuous mammae or absence of a baculum for females. No method of sexing kits was established.

All beavers trapped were classified as either kits, yearlings, two-year-olds, or adults, by weight, sexual activity and established-age animals.

Beaver activities as manifested by structures, plant cuttings, and scats were

recorded to aid in the interpretation of usage of colony sites. Dam building activity was greatest near the first of September. Scent mound activity was greatest in July. Food cuttings were principally willow. Aquatic plants were heavily utilized in August. Three sizes of scats, large, medium, and small were recognized and were believed to be associated with age classes.

Nine colony sites were arbitrarily chosen on the basis of groups of structures. Populations and movements based on trapping and activities were presented by these sites.

Movement from the study area was suggested by six live-trapped yearlings which were not recaptured. Two, caught when yearlings and recaptured when two-year-olds, indicated movement from their original sites. Three live-trapped as kits, and later recaptured, supplied evidence suggesting movement occurred during the second year of life. Activities of two-year-olds handled during the summer suggested their time of "settling" was late summer.

Adult males were found to make considerable summer movements. None was found with breeding females in April, July, or August. Four were found in areas with breeding females in September and March. Data were not available for the other months. Non-breeding females possibly showed a movement similar to adult males. Breeding females showed relatively little movement. Instances of group movement were limited to two successive yearly moves by a group of possibly three beavers.

Territorial behavior of residents rather than grouping of beaver structures appeared to delimit colony boundaries in at least two instances.

The home range of a breeding female was reduced following the "settling" of another breeding female in the same group of structures; indicating population pressure may determine colony limits.

The numerical population, and sex and age composition of colonies were subject to both seasonal and yearly changes.

A successful female may become the maternal member of a family group consisting of kits, yearlings, and, in late summer, fall, and winter, possibly an adult male. This would not necessarily be a "typical" colony, but the potentially ultimate or maximum colony.

LITERATURE CITED

ALDOUS, S. E. 1938. Beaver food utilization studies. Jour. Wildlife Mgt., 2: 215–222.

———. 1940. A method of marking beaver. Jour. Wildlife Mgt., 4: 145–148.

BOOTH, W. E. 1950. Flora of Montana, Part 1, Conifers and Monocots. The Research Foundation of Montana State College. 232 p.

BRADT, G. W. 1933. Report on nuisance beaver control. 1931. Mich. Acad. Sci., Arts, and Letters, 17: 509–513.

———. 1938. A study of beaver colonies in Michigan. Jour. Mamm., 19: 139–162.

———. 1939. Breeding habits of beaver. Jour. Mamm., 20: 486–489.

BURT, W. H. 1943. Territoriality and home range concepts as applied to mammals. Jour. Mamm., 24: 346–352.

COOK, D. B. 1943. History of a beaver colony. Jour. Mamm., 24: 12–18.

DIXON, W. J. AND F. J. MASSEY, JR. 1951. Introduction to statistical analysis. Ed. 1. McGraw-Hill Book Co. 370 p.

FERNALD, M. L. 1950. Gray's manual of botany (Ed. 8). American Book Co. 1632 p.

GRASSE, J. E. AND E. F. PUTNAM. 1950. Beaver management and ecology in Wyoming. Bul. 6, Wyoming Game and Fish Commission, Cheyenne.

HAMMOND, M. C. 1943. Beaver on the Lower Souris Refuge. Jour. Wildlife Mgt., 7: 316–321.

JOHNSON, C. E. 1927. The beaver in the Adirondacks: its economics and natural history. Roosevelt Wild Life Bul., 4: 501–641.

SOPER, J. D. 1937. Notes on the beavers of Wood Buffalo Park, Alberta. Jour. Mamm., 18: 1–13.

TEVIS, L., JR. 1950. Summer behavior of a family of beavers in New York State. Jour. Mamm., 31: 40–65.

WARREN, E. R. 1926. A study of the beaver in the Yancy region of Yellowstone National Park. Roosevelt Wild Life Ann., 1: 13–191.

Montana Fish and Game Department, Helena, Montana. Received August 1, 1952.

ECOLOGICAL RELATIONSHIPS OF MEADOW VOLES AND RICE RATS IN TIDAL MARSHES

BY VAN T. HARRIS

Observations and studies of meadow vole (*Microtus pennsylvanicus*) and rice rat (*Oryzomys palustris*) populations in tidal marshes were made for the purpose of determining some of the relationships between these species and muskrats (*Ondatra zibethica macrodon*) whose houses they frequently inhabit. Furthermore, although meadow voles are known to inhabit coastal marshes, little has been previously recorded of their ecological relationships in this habitat. The fluctuating water levels of tidal marshes, as compared with upland marshes and wet meadows, must impose additional problems of survival on vole populations.

Studies were made from July, 1949, to June, 1951, on three units of the Blackwater National Wildlife Refuge, and on an adjacent privately owned marsh, in Dorchester County, Maryland. Both live-traps (made from tin cans and museum special traps) and snap-traps (museum special and ordinary mouse traps) were used in the study. Three areas, portions of units 3, 4, and 9, were systematically trapped with snap-traps during 1950 and 1951, and the private marsh during 1950. The unit 3 area was live-trapped during both years. Other trapping was done occasionally on these and other areas with a few traps.

The work was done incidental to a muskrat investigation supported by a Rockefeller grant to the Division of Vertebrate Ecology, School of Hygiene and Public Health, The Johns Hopkins University. The Maryland Game and Inland Fish Commission and Department of Research and Education cooperated in the muskrat study, and permission to use the Blackwater National Wildlife Refuge was granted by the U. S. Fish and Wildlife Service. David E. Davis of the Johns Hopkins University kindly read the manuscript and offered suggestions. Facilities of the Institute of Human Biology, University of Michigan, were used in the preparation of the manuscript.

Habitat.—The Blackwater Refuge includes approximately 10,000 acres of brackish-water marshland lying along the Blackwater River which empties into the Chesapeake Bay. Most of the vegetation of the marshes may be grouped into

two main plant communities. Stands of three-square sedge (*Scirpus olneyi*) cover extensive areas of the less saline marshes. On the more brackish marshes, the three-square gives way to salt grass communities composed of varying proportions of *Spartina patens*, *S. alterniflora*, and *Distichlis spicata*. These three species also occur in limited stands along the rivers in the three-square community, and *S. patens* and *D. spicata* occur as broken zones bordering the landward edges of the marsh.

Water depths on the marsh were measured at 15 stations at approximately weekly intervals for 18 months. Tides largely determine water levels, but precipitation has some effect. The tides are greatly influenced by the wind, and over most of the marsh are irregular in onset and duration. Water levels are usually higher during summer than during winter, when they are below the soil surface most of the time because of prevailing northwest winds. Unusually high tides occur during the spring and fall equinoxes. During the study period, water levels varied from 11 inches below the soil surface to 13 inches above, but the usual range was from four inches below to four inches above. Water usually covers the surface for three to five days at a time, but occasionally for a week or longer. Water depth records for a year suggest that water covers the soil surface of the marsh about half the time.

Activities of meadow voles and rice rats.—Meadow voles were apparently more common in the three-square community than rice rats. All trapping, carried out largely in the three-square community, yielded 121 voles and 78 rice rats. This difference in abundance between the two species is suggested also by the food habits of predators.

Meadow voles were taken at muskrat houses and feeding platforms, in old muskrat leads, and in small openings in the three-square. Paths leading from their holes in muskrat houses were distinct for short distances, but soon disappeared in old muskrat runs and in natural openings in the vegetation. In salt-grass stands and in stands of three-square mixed with salt grass, vole paths could be traced for some distance. In these paths and at the entrances of holes in muskrat houses, piles of cut stems of *S. patens*, *D. spicata*, and occasionally of three-square were found. Similar piles of sectioned stems were often noted away from vole paths and occasionally voles were taken there. Such feeding spots appeared to be only temporarily used. Sometimes these food piles seemed to be so constructed that they could have been used as feeding platforms when water covered the surface of the marsh.

Meadow voles build globular nests of fine grasses in muskrat houses. Tunnels are cut through the mass of dead vegetation, as was observed by Rhoads (1930), and may be extensive in houses unoccupied by muskrats. On the marsh surface, nests are frequently built among the plant stems at or near the ground. After the marshes were burned in winter, nests were easily found, and seemed to be more frequent in stands of salt grass than in three-square stands. On two occasions, immediately after fires, surface nests were found to contain unharmed young.

Within the three-square community, meadow voles were common on the unit 3 area and on the private marsh where the roots of the three-square formed a

relatively strong mat. They were less common on unit 9 area where a vegetational mat was fragmentary.

Meadow voles are not strictly nocturnal in tidal marshes. They were often observed during the day in this study.

Rice rats were also taken at muskrat houses and feeding platforms, in muskrat leads, and in small opening in the vegetation. Their activities seemed to result in less sign that those of the meadow vole. Approximately 40 per cent of 86 rice rat captures were made at trap stations showing no small-mammal sign, while only 11 per cent of 144 vole captures were made at such stations. No nests known to belong to rice rats were observed either in muskrat houses or in the marsh vegetation, and only a few paths were noted that might have been made by rice rats. One rice rat, caught in a large wire trap set in shallow water, pulled a considerable amount of vegetation through the wire to form a platform as described by Worth (1950). Rice rats were rarely observed in the daytime in this study.

Effect of water level on the meadow vole population.—The means by which meadow voles survive tides which cover the marsh with several inches of water for several days are not readily apparent. At first it appeared that the voles must depend on the protection of muskrat houses to survive high tides. (The term houses, as here used, include feeding shelters and old houses as well as those occupied by muskrats.) Records of sign, probably including rice-rat sign, occurring at muskrat houses on the unit 3 area of approximately 20 acres, indicate that the houses provided shelter for voles from the higher tides. During July, 1950, after the surface of the marsh had been covered by one or 2 inches of water for several days, sign was found at 25 per cent of 48 muskrat houses. When the marsh was covered by a foot of water during September, 1950, sign was recorded at 72 per cent of 60 muskrat houses. Again, in December, sign appeared at 41 per cent of 69 houses a week after an especially high tide. Evidently the higher tides affect voles to a greater extent than the more usual ones. It is not certain whether high tides cause voles to move to the muskrat houses from the marsh, or whether they merely restrict the activity of the voles to the immediate vicinity of the houses so that the sign is more concentrated and therefore more apparent.

On the other hand, tracks and paths of voles have been observed in marshes where few muskrat houses were present. For example, tracks in the mud, forming paths between clumps of salt grass, indicated the presence of voles a few days after a tide had covered a marsh. During an especially high tide in March, 1951, ten muskrat houses in a three-square marsh were torn apart. One or two voles were found in four houses and four voles in one. These numbers of voles in muskrat houses were not unusually large.

Survival during high tides might be accomplished by movement of voles to high land surrounding the marshes or to small islands of high land in the marshes. However, vole sign has been observed in sections of the marsh as much as half a mile from high land, and movements of voles over such distances would greatly expose them. Trapping on several islands of high land, a month after an especially high tide, resulted in the capture of one meadow vole and one rice rat. The vole was taken on a high, grassy island which showed many old runways. A low, grassy

island, covered by the high tide, showed abundant fresh sign but no mice were taken. During two years spent on the marshes, no observations were made that would indicate a large-scale movement by voles to high land during periods when the marsh was covered with water.

Many meadow voles apparently survive periods of high water because of their habit of living in muskrat houses. Others, living close to high land, probably move there for protection. However, some voles seem to be found at distances from high land in areas where muskrat houses are rare or absent. It is difficult to believe that many of these voles can survive even ordinary high tides by scrambling from one grass culm to another. The problem of vole survival in tidal marshes needs more detailed study.

Notes taken in March, 1951, give some insight into the effect of unusually high tides on meadow vole populations. At the peak of the tide, which lasted for about seven days, the water was more than a foot deep over the marsh. Along a quarter mile of the Blackwater River three voles were seen clinging to branches of the high tide bush (*Iva frutescens*) that lined the shore. Along a mile of the river where no bushes were present, three voles were noted clinging to tufts of salt grass extending above the water. Three dead voles were washed to the shore of a pond in the marsh.

It is evident that an unusually high tide will affect the vole population by exposure and drowning. The extent to which it reduces the population is unknown, but it does not exterminate the voles. Fewer voles and rice rats were taken in 1951 than in 1950, but it is not known if this was due to the high tide of March, 1951, and to a previous one in November, 1950, after the trapping period of that year.

In order to survive periods when water covers the soil surface of the marsh, meadow voles must be able to continue their life activities to a satisfactory extent. Meadow voles have been observed to swim and dive by Blair (1929) and Peterson (1947), and both writers indicated that the fur showed evidence of becoming water soaked after relatively short periods in the water. On the Blackwater marshes, meadow voles frightened from muskrat houses readily dive into the water and swim below and on the surface. During a high tide a meadow vole was observed swimming in the river and, at the approach of the boat, it dived much after the fashion of a muskrat. Another vole was caught in a trap set in a mouse path that was covered with an inch of water. In tidal marsh habitats, meadow voles are apparently able to tolerate considerable aquatic activity since they live in the marsh and survive even extreme tides.

Relationships between meadow voles and rice rats, and muskrats.—Rice rats were reported by Stone (1898) and Rhoads (1902) to live in muskrat houses in the brackish marshes of New Jersey. Rhoads (1903) also listed meadow mice and least shrews as inhabiting houses with the muskrats. Since then few references have been made to these mammals in muskrat houses. Harper (1920) records the probable nest of a rice rat in a *Neofiber* house in Georgia, and Ulmer (1944) caught meadow mice and the hair of a rice rat in traps set at muskrat houses in Delaware. In Manitoba, field mice (*Microtus*) were found to be living, during early winter, in association with muskrats (Fuller, 1951).

Trapping was carried out mostly at muskrat houses to determine the extent to which they were infested with mice. Table 1 gives the numbers of voles and rice rats taken. No attempt has been made to convert the catch into population figures because areas between the muskrat houses were often not trapped, and because there was evidence that some voles were present but not caught where traps were set. However, the difference in catch between 1950 and 1951 is believed to reflect a true decrease in population, since differences in quantity of mouse sign were also apparent.

The percentage of muskrat houses at which meadow voles and rice rats were caught on each of the three areas, each year, varied from 11 to 34. During several trapping periods from January through June, 1950, mice were taken at 48 per cent of the houses trapped on unit 3 (Harris, 1952:29).

TABLE 1.—*Localities, trapping data, and catches of meadow voles and rice rats in tidal marshes of Dorchester County, Maryland*

LOCALITY	DATE	APPROX. AREA IN ACRES	TRAP PERIOD IN DAYS	TRAP NIGHTS	VEGETATION	CATCH OF: *Microtus*	CATCH OF: *Oryzomys*
Unit 4	May 1950	4	4	300	Salt-grass zone	8	5
Unit 4	May 1951	4	4	300	Salt-grass zone	5	0
Unit 3*	Mar. 1950	20	4	483	Three-square	25	5
Unit 3*	May 1951	20	4	259	Three-square	9	3
Unit 9*	May 1950	12	4	305	Three-square	3	15
Unit 9*	May 1951	12	3	165	Three-square	3	5
Private Marsh	June 1950	10	5	528	Three-square	17	13

* Trapping mostly at muskrat houses.

Meadow voles and rice rats were taken at houses occupied by muskrats and at houses vacated by muskrats. The total catches at muskrat houses were analyzed in a 2 by 2 table to test the hypothesis of independence between muskrat occupancy of houses and mouse captures at houses. The chi-square values for meadow voles and rice rats (1.69 and 0.03, respectively) are not significant at the 1 per cent or 5 per cent levels, indicating that differences between mice taken at occupied houses and at vacated houses could have been due to sampling variations. None of the chi-square values obtained by analyzing the captures for each trapping period in each area were significant. *Microtus* was taken at occupied houses 15 times and not taken 75 times; at vacant houses it was taken 13 times and not taken, 110. *Oryzomys* was taken 11 times in occupied houses and not taken 79 times; at vacant houses it was taken 16 times and not taken 107 times.

At times there was evidence that mice were present at muskrat houses where they were not caught, and further, we cannot say that a particular mouse lived in the muskrat house where it was caught. However, it is believed that the trapping was an adequate indication that mice showed no greater preference for houses inhabited by muskrats than for those deserted by muskrats.

By living in muskrat structures, mice gain protection from weather and tides. They use old muskrat leads in their movements through the marsh and probably profit from bits of food left by muskrats. No advantage to the muskrat is sug-

gested by the relationship. The circumstantial evidence from mouse trapping at occupied and unoccupied muskrat houses would indicate that neither muskrat nor mouse was directly harmed by common occupancy of muskrat houses. If the presence of muskrats were detrimental to mice, the mice would be found more frequently in unoccupied houses. If mice were not tolerated by muskrats, the mice again would be more frequent in unoccupied houses, whether they were driven away or avoided by the muskrats. The relationship might be indirectly harmful to either muskrat or mouse if raccoons and other predators that dig into muskrat houses after one species, disturb or feed on the other. Another possible effect on the muskrats might be increased aeration in the houses caused by the mouse holes. The few observations that mouse holes were occasionally plugged probably resulted from a general repairing activity by the muskrats.

Trapping, marking, and recapturing meadow voles and rice rats provided data on their movements and relationships. The live-traps were not placed in a grid pattern, but they gave a good coverage of a 3⅔ acre plot on the unit 3 area. Trap locations were determined to the nearest five feet by pacing from stakes established by tape measure at 100-foot intervals.

The maximum distance between capture points for individuals taken three or more times averaged 245 feet for six rice rats and 125 feet for 11 meadow voles. A maximum distance of 270 feet between captures was recorded for one of six *Oryzomys palustris natator* retrapped in northern Florida (Pournelle, 1950). The average maximum distances between catches of meadow voles given here indicate a home range more comparable to that of the meadow vole in Michigan (½ to ¼ acre, Blair, 1940) than in New York (1/15 acre, Hamilton, 1937).

All mice that were caught more than once at muskrat houses were caught at more than one house. Five rice rats averaged three captures each at muskrat houses and an average of 2.8 of these captures were at different houses. Six meadow voles averaged 2.7 captures each at houses, an average of 2.3 captures being at different houses. Six of 7 rice rats caught 2 or more times were each taken both at muskrat houses and at other trap stations, and the seventh was never taken at a house. Of 21 meadow voles caught more than once, 10 were taken only at stations away from muskrat houses, 6 only at muskrat houses, and 5 at both types of trap positions.

More than one individual of a species and more than one species were sometimes caught at a muskrat house. The following figures were derived from snap-trap and live-trap captures made over periods of four to five days. In a total of 43 houses yielding meadow voles, two individuals were taken from ten houses and three individuals from two houses. In all but two cases in which two or more voles were taken at a house, they could have been pairs, or adults and/or litters not yet dispersed. Of 41 houses yielding rice rats, two individuals were taken in each of two houses, and one at each of the others. Meadow voles and rice rats were taken at eight houses: one each at six houses, and one rice rat and two meadow voles and one rice rat and three voles each from one house. One vole and a house mouse (*Mus musculus*) came from one house, and a vole, a house mouse, and a rice rat from another. On the basis of this trapping, rice rats and meadow

voles apparently infrequently lived together in a muskrat house. More than one vole in a house was usually due to breeding aggregations.

Reproduction.—Meadow voles and rice rats taken dead during March, May, June, and July were examined for embryos, and the percentage of the mice containing embryos and the average number of embryos are recorded in Table 2. In addition, two surface nests were found containing young meadow voles on December 8, 1949 and on January 25, 1950. A meadow vole nest in an unused muskrat shelter contained young on January 29, 1951. Evidently the meadow vole breeds most of the winter in parts of Maryland and does not necessarily rely on special protective cover for winter breeding. Brimley (1923), in the vicinity of Raleigh, North Carolina, found embryos of *Microtus pennsylvanicus* during January, March, April, October, and November, and young during January, June, November, and December. For the rice rat, my few data accord with those of Brimley, whose records indicate that rice rats breed during the months of March to November inclusive.

TABLE 2.—*Presence and average number of embryos for meadow voles and rice rats in a tidal marsh habitat*

	Microtus			*Oryzomys*		
MONTH	NUMBER EXAMINED	PER CENT WITH EMBRYOS	AVERAGE NUMBER EMBRYOS	NUMBER EXAMINED	PER CENT WITH EMBRYOS	AVERAGE NUMBER EMBRYOS
March	14	71	4.3	1	0	—
May	10*	40	4.3	10	20	5.5
June	5	60	3.0	1	100	6.0
July	5	40	3.0	4	100	5.5

* Four without embryos showed evidence of suckling.

Of 113 meadow voles taken during the study period in marsh habitat, 49.6 per cent (56) were males. Males (49) constituted 63.6 per cent of 77 rice rats, which is a significant deviation ($\chi^2 = 5.72$) from a 1 to 1 ratio of males to females for trapped animals.

Meadow voles and rice rats as prey.—Table 3 records data on the percentage of occurrence of rice rats, meadow voles, and other small mammals in stomachs (and/or intestines), scats, and pellets of certain predators. Pellet analysis was based on the identification of skulls and bones in the pellets. The pellets found on muskrat houses and occasionally on matted salt grass were most certainly produced by the marsh hawk (*Circus cyaneus*). Marsh hawks regularly hunted the area and the pellets in question were uniform in size, shape, and appearance and were the type most commonly found on the marsh.

Rice rats occurred to a less extent than meadow voles in the food remains of raccoons (*Procyon lotor*), foxes (probably all *Vulpes fulva*), barn owls (*Tyto alba*), and marsh hawks, suggesting that rice rats were less common than meadow voles in the marshes. The percentages of occurrence of voles were approximately the same in the pellets of barn owls and marsh hawks, but the percentage of occurrence of rice rats was nearly twice as great in barn owl (nocturnal) pellets as in

marsh hawk (diurnal) pellets. This suggests that rice rats are more strictly nocturnal than meadow voles.

Rice rats and, to a greater extent, meadow voles form a substantial part of the prey of the four species of predators studied. These mice may act to some extent as a buffer prey to adult muskrats for raccoons and foxes, since they are presumably more easily caught. On the other hand, their presence in muskrat houses may increase predation on nestling muskrats because of the predators' habit of digging into muskrat houses. The buffer status of the mice is very difficult to evaluate since the preferred prey of the predators are unknown.

TABLE 3.—*Data and percentage of occurrence of meadow voles, rice rats, and unidentified small mammals in food habit materials of four predators in Dorchester County, Maryland. Some remains of either rice rats or meadow voles could not be distinguished and they make up much of the unidentified category*

SOURCE OF DATA					ANALYSIS		
Species	Material examined	Number examined	Dates of collection	Habitat	Per cent of material containing: *Microtus*	*Oryzomys*	Unidentified small mammals
Raccoon	Stomachs*	150	July, 1949–May, 1951	Marsh and vicinity	13.3	3.3	8.7
Red fox	Stomachs*	17	July, 1949–June, 1951	Marsh and vicinity	47.1	5.9	5.9
Raccoon	Scats	301	Nov., 1949–June, 1951	Marsh	17.6	4.0	4.3
Fox	Scats	103	Nov., 1949–June, 1951	Marsh	49.6	4.8	8.7
Barn owl	Pellets	130	Feb., 1950–Apr., 1951	Marsh and edge	71.5	26.9	6.0
Marsh hawk (?)	Pellets	79	Nov., 1949–June, 1951	Marsh	73.4	15.2	3.8

* "Stomachs" means stomachs and/or intestines.

During a year, from 68 to 76 per cent of the houses dug into by raccoons are houses occupied by muskrats (Harris, 1952:26). This was especially noticeable in spring during the beginning of the muskrat breeding season. Together with the indication that mice inhabit muskrat houses independently of muskrat occupancy, this would suggest that muskrats attract raccoons to a greater extent than mice. However, certain occasions have been noted, especially during winter, when raccoons have apparently torn into all muskrat houses, including very old ones.

Summary.—Studies of rice rats and meadow voles in brackish, tidal marshes of Dorchester County, Maryland, were made incidental to a muskrat investigation. The marshes are dominated by three-square sedge and salt grass communities, and the water level usually fluctuated from four inches below the soil surface to four inches above. Trapping yielded 121 meadow voles and 78 rice rats. Some activities and habits of the mice are described. Some voles are protected from

high tides by living in muskrat houses, but for others the means of protection is obscure. The presence of meadow voles in the marsh indicates some adaptation to an intermittently aquatic habitat. During trapping periods of several days, meadow voles and rice rats were taken at 11 to 34 per cent of muskrat houses, but over a longer period they were taken at 48 per cent. Chi-square analysis of trapping data indicates that these mice lived no more frequently in houses occupied by muskrats than in unoccupied houses. Muskrat houses provide mice with protection from weather and tides, but muskrats appear to be neither benefited nor harmed by the relationship. The greatest distances between captures of six rice rats averaged 245 feet, and 11 meadow voles averaged 125 feet. Both species included more than one muskrat house in their ranges of activity. Two species were infrequently caught at a house, and more than one vole appeared to be due to breeding aggregations. Meadow voles do not require the special protection of muskrat houses for winter breeding. Voles and rice rats form a substantial part of the diet of raccoons, foxes, barn owls, and marsh hawks. Some evidence suggests that in muskrat houses, muskrats attract raccoons to a greater extent than mice.

LITERATURE CITED

Blair, W. F. 1939. A swimming and diving meadow vole. Jour. Mamm., 20: 375.

———. 1940. Home ranges and populations of the meadow vole in southern Michigan. Jour. Wildlife Mgt., 4: 149–161.

Brimley, C. S. 1923. Breeding dates of small mammals at Raleigh, North Carolina. Jour. Mamm., 4: 263–264.

Fuller, W. A. 1951. Natural history and economic importance of the muskrat in the Athabasca-Peace Delta, Wood Buffalo Park. Dept. of Resources and Development, Nat. Parks Branch, Canadian Wildlife Serv., Wildlife Mgt. Bul., Ser. 1, No. 2, 82 p.

Hamilton, W. J., Jr. 1937. Activity and home range of the field mouse, *Microtus pennsylvanicus pennsylvanicus* (Ord.). Ecology, 18: 255–263.

Harper, F. 1920. The Florida water rat (*Neofiber alleni*) in Okefinokee Swamp, Georgia. Jour. Mamm., 1: 65–66.

Harris, V. T. 1952. Muskrats on tidal marshes of Dorchester County. Dept. of Research and Education, Chesapeake Biol. Lab., Publ. 91. 36 p.

Peterson, R. L. 1947. Further observations on swimming and diving of meadow voles. Jour. Mamm., 28: 297–298.

Pournelle, G. H. 1950. Mammals of a north Florida swamp. Jour. Mamm., 31: 310–319.

Rhoads, S. N. 1902. The marsh or rice-field mice of the eastern United States. Amer. Nat., 36: 661–663.

———. 1903. Mammals of Pennsylvania and New Jersey. Privately Published, Philadelphia. 266 p.

Stone, W. 1898. Occurrence of *Oryzomys palustris* in southern New Jersey. Proc. Acad. Nat. Sci. Philadelphia: 480–481.

Ulmer, F. A., Jr. 1944. Further notes on the rice rat in Delaware. Jour. Mamm., 25: 411.

Worth, C. B. 1950. Observations on the behavior and breeding of captive rice rats and woodrats. Jour. Mamm., 31: 421–426.

U.S. Fish and Wildlife Service, Lafayette, Louisiana. Received August 9, 1952.

PHOCOENOIDES AND *LAGENORHYNCHUS* IN JAPAN, WITH NOTES ON HUNTING

By Ford Wilke, Takeshi Taniwaki, and Nagahisa Kuroda

Porpoise hunting in Japan is a well developed phase of whaling. It has no counterpart in the United States where labor and operating costs are so high that to capture and market these small cetaceans would be unprofitable. In Japan, where until 1949 the demand for porpoise products was apparently unlimited, the vessels engaged in porpoise hunting increased in number each year until it was approximately at the pre-war level in the 1949 season. Thus far, the catch per vessel is said to be larger than prewar, although actual catch statistics are not recorded. The porpoise and dolphin catch is so much greater in Japan than in any other region of the world that it offers an unrivaled opportunity for scientific work. (A single company landed 465 right-whale dolphins, *Lissodelphis borealis*; 697 striped dolphins, *Lagenorhynchus obliquidens*; and one True porpoise, *Phocoenoides truei*; off Onahoma, Fukushima Prefecture, in May and June 1949.)

Hunting.—Most of the hunting takes place off the Pacific coast of northern Honshu and off the Pacific and Okhotsk sea coasts of Hokkaido. Our observations were made there. The season begins in March near Choshi, Ibaraki Prefecture. By mid-March large schools appear as far north as Hosoura, Iwate Prefecture. Hunting continues along this coast until June, when most of the activity moves northward to Hokkaido for the summer. Some hunting may be resumed in the autumn from Fukushima and Ibaraki prefectures but spring is the principal season on Honshu. Hunting extends 30 miles from the coast although most of it is concentrated in the area from 10 to 15 miles offshore. No legal protection is given dolphins or porpoises in Japan and they may be hunted whenever and wherever they occur.

Harpoon vessels of 20–30 tons, called *tsukimbo-sen* by the Japanese, carrying a crew of 10–12, are employed during the autumn and spring for porpoise hunting, and for swordfish and shark hunting in the summer. They are powered by semi-diesel "hot head" or diesel engines that give a speed of 7 to 10 knots. A wooden platform projection over the bow from which to shoot and harpoon is the most distinctive feature of these craft. Each vessel is equipped with a supply of hand harpoons fitted with detachable steel heads. The head is knife-like in sharpness and has a short, cable-wire leader attached midway between the barbed point and the ferrule of throat so that the head turns in the flesh of the porpoise and the pull is directed against the entire area instead of merely against the barbs. The solid steel point of the 12-foot wooden shaft is forced into a wooden plug fitted in the ferrule of the harpoon head. In operation the shaft is supposed to pull loose from the head and float free of the dolphin but is held to the harpoon line by lashing (Fig. 1). Actually, the shaft often remains imbedded in the head and its steel point becomes badly bent in the struggle of hauling the porpoise aboard. Harpoon lines of 800-pounds test, which are about one-fourth inch in diameter and made of manila or cotton fibre, are kept coiled in bamboo splint baskets. Small sealed casks are ready to be tied to the harpoon line and dropped overboard as floats in the event that more than one porpoise has been harpooned or it is necessary to quickly clear the bow of the vessel to continue harpooning.

For most species of porpoises and dolphins a harpoon is merely an instrument for recovering, before the carcass sinks, an animal that has been killed with buckshot fired from a shotgun. True porpoises, which are not wary of vessels and frequently play at the bow of a moving ship, may be harpooned without shooting. This is true to a lesser extent of any small cetacean which may approach a ship closely but remains underwater where it cannot be shot. Many animals can be taken by shooting that could never be reached with harpoons.

Dolphins are not hard to kill with a charge of buckshot but are difficult to hit. They emerge and dive so quickly that success often depends as much on skill in anticipation as skill in shooting. Whenever possible the hunter follows the underwater passage of the porpoise with his gun muzzle and shoots as it breaches for air. A single vessel has taken over 200 in a day.

When dead, the animal's tail sinks so that the body floats with the snout projecting above water. Of fourteen striped dolphins shot on March 14, five sank before they could be harpooned. About one-third of the True and Dall porpoises shot in 1950 were lost. Others floated easily for several minutes. Hunters claim that a belly shot causes an animal to

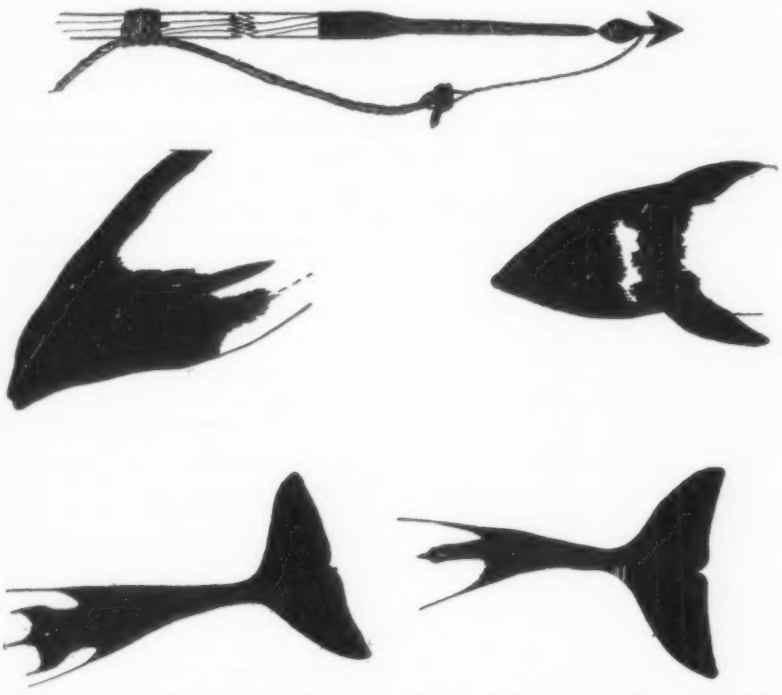

FIG. 1.—UPPER. Japanese hand harpoon for dolphins and porpoises. LOWER. Variation in the color pattern on the throat, pectoral girdle, and the circumanal area of the True porpoise.

sink. A floating striped dolphin was observed to exhale violently, after which it sank immediately. Seizamo Hamada, a prominent porpoise hunter of Ozuchi, Iwate Prefecture, says he has often found dolphins floating on the sea that had been shot a day or two previously.

Utilization.—Porpoises and dolphins are prepared for sale in the following manner:

Flippers, fin, and tail sliced off.

Hide and blubber slit longitudinally from snout to tail along both back and belly, and peeled off together in two sections. The hide is often tanned into a low grade leather said to be strong in one direction but weak when strain is applied from the opposite way. Oil is extracted from the blubber.

Head disarticulated from rest of carcass. Fat deposits on top of head and at the angles of the jaws are removed as a source of fine machine oil.

Flesh sliced along vertebral projections. It can be removed in a single strip from each side of the vertebral column. After chopping through the ribs the belly sections are also free. All flesh is sold for human food. It is dark in color but palatable.

Viscera are removed. The heart, liver, and kidneys are saved for food and the remainder becomes fertilizer. At north Honshu ports the viscera are discarded before the animals are brought in for sale.

Skeleton saved for fertilizer.

The market value of a porpoise in 1948 was ¥2,000 to ¥3,000 (¥360 = $1.00). On the black market the price of porpoise meat was two and a half times the legal price. As might be expected, most of the flesh found its way into the black market. A sharp decline in price took place in 1949 after porpoises, along with fish and certain other food items, were removed from rationing controls.

Behavior.—Rapidly swimming species such as the striped and common dolphin may be seen in schools a mile from the vessel as they breach sharply, creating white splashes, or jump clear of the water. Because of the shape of the dorsal fin, striped dolphins are known to the Japanese as *kama-iruka*, meaning sickle dolphin. True and Dall porpoises often slash rapidly through choppy water thereby making themselves visible from a long distance. The same species in small groups may betray their presence only by the quiet emergence of the dorsal fin. When True or Dall porpoises become aware of a moving vessel they may come rushing in at it, to run before the bow, quickly charging from side to side. They sometimes appear suddenly alongside the ship, startling the unobservant watch with a quick, sharp, snuffing sound as they blow. Infrequently, the same behavior can be expected from dolphins. The course of the hunting vessel is altered to intercept approaching schools of dolphins in an attempt to come within shotgun range. However, they are elusive and if they come within less than 40 yards of a ship, they will dive and dart rapidly underneath at depths of 3 to 10 feet. By a combination of skill and luck it is sometimes possible to harpoon an animal as it glides across under the bow.

On March 13 a school of striped dolphins that was at least one and one-half miles across was located ten miles northeast of Onagawa. Over thirty minutes were required for it to pass at a rate two or three knots faster than the speed of the ship. The dolphins were swimming rapidly in a southwesterly direction toward shore; whole ranks of several hundred breaching as one. Occasionally one would leap repeatedly almost straight up and fall on its back or side, with a heavy splash. When within 15 miles of Kinkazan they appeared to lose their desire for urgent flight and began to forage about in various directions. Later in the season herds of striped dolphins often are accompanied by many right-whale dolphins.

On this same occasion three groups of three to five animals were observed in which a pair was obviously copulating. The white belly of one gleamed upward and there was a great deal of thrashing about and lashing of flukes above the surface. An apparent preponderance of males in one school (of nine taken, all were males) suggests that the female is attended by several males. These groups were not so engrossed as to neglect to dive before the vessel came within shotgun range. A female striped dolphin taken March 7, while feeding in a school of anchovies, carried a fetus 761 mm. long. It was curled so that the head and flukes were touching; the dorsal fin was folded down on the back, and the flukes rolled. The curve of the back was nearest the genital orifice. A few vibrissae were present on the snout, a feature never found on an adult.

Some sexual segregation also occurs among True porpoises. All of fourteen animals taken between March 25 and May 12, 1950, were males. They came from many schools and over a north, south distance of seventy miles. With one exception, ten others collected from Miyako, Iwate Prefecture, and north, in the latter half of May, were females. It will remain for a future collector to determine whether, in spring, the southern part of the range is occupied by males and the northern part by females or whether our runs of males and females were accidental.

Measurements.—In Table 1, the maximum, minimum, and mean weight and body measurements of ten male and three female striped dolphins are given. Table 2, which compares conventional measurements of True and Dall porpoises does not reveal any important differences of proportion. Table 3 gives the measurements of one fetus from a Dall, and one from a True, porpoise.

A pregnant female captured near Erimo-Saki, Hokkaido, on May 24, had a ten pound fetus (Table 3). On the previous day, an adult in a school of four was closely followed by a brownish-gray young, noticeably lighter in color than the glossy black adults. The calf was about half as long as the mother. The analysis of a thick yellowish fluid present in the mammary glands of a pregnant True porpoise (as determined by the Department of Chemistry, 406th Medical General Laboratory, U. S. Army) was: fat, 2.2 per cent; moisture, 66.2 per cent; and protein (N × 6.38), 31.6 per cent.

TABLE 1.—*Measurements of 15 striped dolphins from Miyagi Prefecture, Honshu, Japan 1949 (millimeters)**

	4 FEMALES		10 MALES		FETUS**
	Mean	Range	Mean	Range	
Length, tip of snout to base of notch in flukes	1723	(1617–1833)	1671	(1603–1788)	761
Weight (pounds)	176	(148–205)	147	(128–186)	—
Girth immediately behind flippers	1032	(987–1097)	965	(908–1005)	368
Maximum width of tail flukes	498	(472–517)	438	(400–502)	189
Snout to tip of dorsal fin	1123	(1010–1205)	1065	(1014–1131)	507
Snout to anterior insertion of flipper	431	(410–447)	419	(403–443)	209
Axillary length of flipper	302	(285–323)	281	(257–295)	148
Maximum width of flipper	111	(103–116)	106	(101–116)	61
Height of dorsal fin	199	(187–216)	184	(164–204)	85
Tail notch to center of anus	496	(486–524)	492	(468–658)	221
Snout to corner of mouth	230	(222–238)	226	(218–239)	117
Snout to center of eye	277	(267–284)	270	(263–283)	142
Snout to slit of blowhole	291	(279–307)	285	(269–294)	147
Projection of lower jaw beyond snout	8	(5–11)	6	(5–6)	3
Length of beak, dorsally	40	(27–54)	33	(32–40)	16

* One female was taken in 1950. ** Male, collected March 7, 1949.

Range of Phocoenoides in Japan.—Our most southerly record in 1950 for the Dall porpoise was about 40° 50′ north latitude, 17 miles NE of Same, the port of Hachinohe in Aomori Prefecture. Here, on May 16, 1950, we captured two females out of a school. In 1952, Dall porpoises were taken down to 39° north latitude.

True porpoises were taken from 20 miles west of Kinkasan Peninsula at about 38° 15′ north latitude to 24 miles SE of Erimo-Saki, Hokkaido, at nearly 42° 00′ north latitude. These specimens establish an overlap in the Pacific coast ranges of the two porpoises of at least 1° 10′, or 70 miles.

Tsurumatsu Kawaguchi, a porpoise hunter of wide experience along the Pacific side of northern Japan, stated that he had never taken True porpoises north of Kushiro, Hokkaido. Dall porpoises, though, are common northward and occur in great schools in the Okhotsk Sea off Abashiri. At times in July and August the white water created by the animals plunging through the sea chop can be seen from the town of Abashiri. Individual harpoon ships have taken up to 80 Dall porpoises in a day. The Dall porpoise is also reported in the Sea of Japan (Noguchi, 1943; Matsui and Noguchi, 1946; Matsuura, 1943). Lacking personal experience in the Japan Sea we are unable to verify these reports.

TABLE 2.—*Comparative measurements (in millimeters) of 20 True* and 4 Dall porpoises from northern Japan*

	FEMALES						MALES					
	9 *P. truei*			2 *P. dalli*			11 *P. truei*			2 *P. dalli*		
	Mean	Range	Per cent of length	1	2	Per cent of length	Mean	Range	Per cent of length	1	2	Per cent of length
Length, snout to base of tail notch	1774	(1692–1852)	100.0	1985	1723	100.0	1850	(1721–2077)	100.0	1915	1747	100.0
Weight, pounds	209	(200–253)	—	320	179	—	225	(185–260)	—	260	235	—
Girth immediately behind flipper	954	(900–1026)	53.8	1081	912	53.7	983	(932–1034)	53.1	993	1014	54.8
Maximum width of tail flukes	482	(421–560)	27.2	616	461	29.1	506	(492–563)	27.4	558	491	28.7
Snout to tip of dorsal fin	961	(914–1052)	54.2	1034	917	52.6	938	(865–1029)	50.7	978	899	51.3
Snout to insertion of flipper	304	(283–319)	17.1	310	310	16.7	308	(290–335)	16.6	290	296	16.0
Axillary length of flipper	180	(170–200)	10.1	200	170	10.0	184	(171–204)	9.9	173	178	9.6
Maximum width of flipper	101	(91–111)	5.7	109	94	5.5	103	(97–111)	5.6	94	101	5.2
Height of dorsal fin	169	(152–200)	9.5	132	171	8.2	176	(155–186)	9.5	196	166	9.9
Tail notch to center of anus	553	(497–610)	31.2	636	535	31.6	576	(523–634)	31.1	625	579	32.9
Corner of mouth to snout	115	(106–124)	6.5	117	115	6.3	115	(106–125)	6.2	115	117	6.3
Snout to center of eye	221	(212–231)	12.5	229	212	11.9	226	(207–238)	12.2	207	217	11.6
Snout to slit of blowhole	227	(218–242)	12.8	240	225	12.6	227	(209–243)	12.3	217	212	11.7
Projection of lower jaw, beyond snout	42	(35–47)	23.7	38	—	20.5	42	(39–52)	22.7	33	40	20.2

* One female taken March 1949; others, March to May 1950.

Matsuura reports the True porpoise as far south as Choshi (36° north latitude) in the Pacific Ocean and Noto Peninsula (37° north latitude) in the Japan Sea. Hunters say that True and (or) Dall porpoises are abundant and the hunting is good in the waters immediately south of Hokkaido during June and July. We did not find them especially numerous there in 1952.

Apparently the Dall porpoise is a more northern type ranging south in the Pacific along Japan as far as Miyagi Prefecture where it is supplanted by the True porpoise. The ranges of the two overlap off northern Honshu and southern Hokkaido.

Systematic status of the True porpoise.—The True porpoise was originally described by Andrews (1911). The illustrations with his description, and those in our present paper (Fig. 1, Pl. I), illustrate the distinctive color pattern. The Dall porpoise is known to Japanese hunters as *ishi-iruka* and the True porpoise, as *rikuzen-iruka*, possibly because it was first described from Rikuzen Province.

TABLE 3.—*Measurements in millimeters of fetal Dall and True porpoises from northern Japan, 1950*

	P. dalli, ♀ MAY 16, 1950	*P. truei*, ♀ MAY 24, 1951
Length, snout to base of tail notch	895	778
Weight, pounds	14	10
Girth immediately behind flippers	429	348
Maximum width of tail flukes	folded	folded
Snout to tip of dorsal fin	folded	folded
Snout to insertion of flipper	150	132
Axillary length of flipper	100	93
Maximum width of flipper	49	41
Height of dorsal fin	73	69
Tail notch to center of anus	225	207
Corner of mouth to snout	60	51
Snout to center of eye	112	101
Snout to slit of blowhole	112	—
Projection of lower jaw beyond snout	4	4

Cowan (1944) concluded that the only valid characters among those given by Andrews as distinguishing *truei* from *dalli* are the greater extent anteriorly of the lateral white patch and the shape of the circumanal area. Benson and Groody (1942) wrote that they regarded *truei* as a synonym of *dalli*. They described a specimen of *dalli* taken in San Francisco Bay as intermediate between the types of *dalli* and *truei*. Benson (1946) stated that ". . . the value of the minor details of pattern as a basis for distinguishing the two kinds when the specimens are so few is certainly open to question."

So far as we know the two types maintain separate color patterns. Individuals of each type may vary in minor respects, as mentioned by Benson and Groody, but in no known instance does the lateral white patch of *dalli* (Pl. I) extend far beyond the anterior margin of the dorsal fin, nor does *dalli* ever have a white patch on the throat as is often found in *truei*. If the two color patterns were merely expressions of individual variations, it would be reasonable to expect individuals of both patterns, or a wide range of patterns, in the same school of porpoises. Actually, all the schools observed were composed solely of one type or the other. Individual variations do occur as shown by a completely dark porpoise taken March 30, 1950, off Onagawa, Miyagi Prefecture, from a school of True porpoises. The dorsal fin, outer half of tail flukes, and areas about the genital and anal openings were dark gray; the rest of the animal was black. If it had not been known to come from a school of True porpoises this patternless animal would have presented an interesting problem in identification.

Far more perplexing was the appearance in May, 1950, of a 14 pound fetus marked, although in indistinct gray tones, like *truei*, in the uterus of a 320-pound *dalli* female. Two explanations are offered. (a) Perhaps all fetal phocoenoids have the *truei* pattern, later assuming the *dalli* pattern if they are of *dalli* parentage (the pattern of a 10 pound fetus

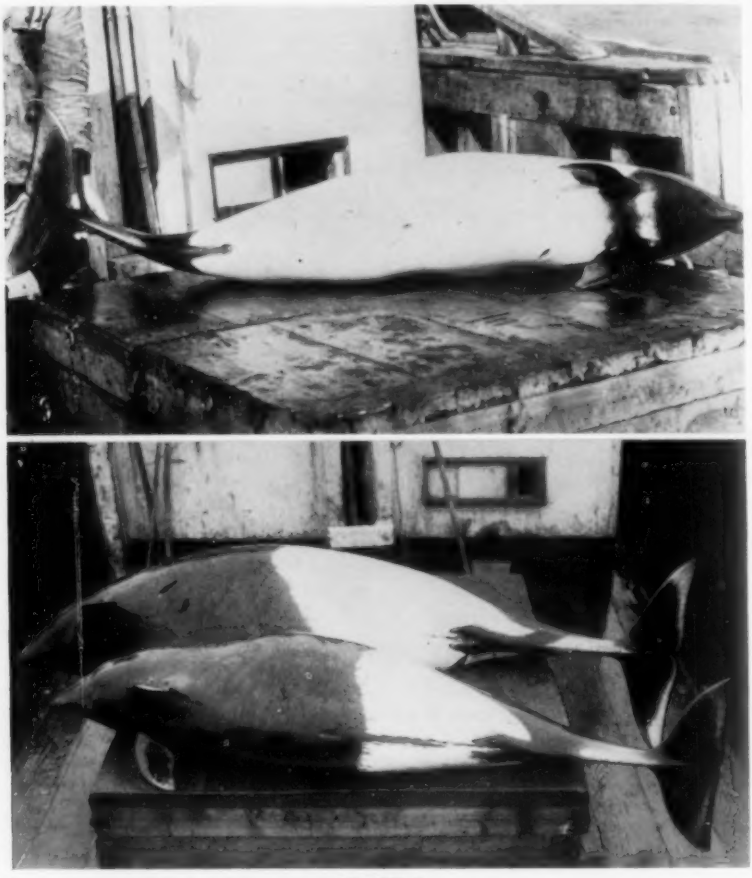

PLATE I

UPPER. Ventral color pattern of a True porpoise. LOWER. Two female Dall porpoises taken off Same, Aomori Prefecture, Japan.

taken 24 May was indistinct). (2) More likely, there is occasional interbreeding between *truei* and *dalli*. Fraser (1940) has suggested the possibility of crossing between *Tursiops* and *Grampus* (*Gramphidelphis*).

In deciding, then, whether *P. truei* should be considered a species or a subspecies, or be relegated to synonomy, we may consider the following evidence: (1) The range of *dalli*, the northerly animal, overlaps the range of *truei*, the southerly animal, nearly 200 miles.

(2) The color patterns of the two are distinct. *P. truei* has a far larger white area extending to the flippers and may have a white throat patch. (3) Body measurements and proportions of the two are alike, discounting individual variation. (4) Each type travels in schools of its own kind. No mixing has been observed. (5) A *dalli* female carrying a fetus marked like *truei* has been collected.

TABLE 4.—*Stomach contents of True and Dall porpoises, and striped dolphins, taken from March to May in northern Japan*

		PER CENT OF FOOD BY VOLUME	NO. OF STOMACHS CONTAINING ITEM
True porpoise, 24 stomachs			
Lantern fish	Scopelidae (Myctophidae), at least two species	70	19
	Sudidae, Parelepis sp.	3	3
Squids	*Watasenia scintillans*	8	14
	Ommastrephes sloani pacificus	5	11
	Unidentified Decapoda, eye lenses, beaks, and pen fragments	2	6
Hake	*Laemonema morosum*, of the family Gadidae	12	1
		100	
Dall porpoise, 4 stomachs			
Squids	*Ommastrephes sloani pacificus*	97	4
	Watasenia scintillans	trace	1
	Unidentified Decapoda	1	1
Hake	*Laemonema morosum*	2	3
		100	
Striped dolphin, 13 stomachs (3 empty)			
Lantern fish	Scopelidae (Myctophidae)	77	7
Anchovy	*Engraulis japonica*	9	1
Squid	Decapoda, beaks and eye lenses, probably *Watasenia scintillans*	7	9
Mackerel	*Scomber japonicus*	7	1
		100	

The preceding observations are sufficient to maintain the status of *truei* as a separate species or subspecies, at least until someone is able to make a more conclusive study. Cowan's suggestion, "It may be that the *truei* pattern is a local variant, perhaps with a definite geographic range in certain Asiatic waters", fits the situation in most respects. However, it is difficult to explain from our present knowledge why the color patterns do not intergrade where the ranges of the two types overlap.

Food.—Lantern fish of the family Scopelidae (Myctophidae) comprised 77 per cent by volume of the food of the striped dolphins (Table 4). Squids, mostly very small species, made up only seven per cent of the volume but had a high frequency of occurrence, appearing in nine out of ten stomachs that contained food. A California specimen recorded by Scheffer (1950) had fed on squids. Higgins (1919) found sardines in another California speci-

men. Squids may be more important than their volume composition in stomach contents indicates. Only their beaks and pens are at all resistant to digestion and these tend to become trapped in the folds of the stomach. Consequently, an insignificant volume of tiny beaks usually remains. It is unknown how long beaks may accumulate,—but probably until they become mixed and eliminated with more bulky non-digestible food debris such as fish bones. The stomach of a single striped dolphin taken off Kinkasan, Miyagi Prefecture, contained the beaks of about 750 small squids. Accumulations of one or two hundred are commonly found.

Lantern fishes were likewise the major food item of the True porpoise, making up 70 per cent of the volume in the 24 stomachs examined. Remnants of squids were contained in many of the stomachs. The most unusual species taken by True porpoises was fish of the family Sudidae, *Paralepis* sp. (Identified by Leonard P. Schultz and William Leapley, Division of Fisheries, U. S. National Museum), which occurred in three stomachs. Most of the members of this family are rare. Some species are represented in fish collections by a single specimen. Porpoises feed on these relatively little known, slender, pike-like fish with regularity. Remains were found in specimens collected in both 1949 and 1950.

The four Dall porpoises examined had fed almost exclusively on two species of squids. In one stomach there were two specimens of a gadid, *Laemonema morosum* (also in a True porpoise stomach), hake-like fish with long filaments on its fins. This fish is commonly taken by deep water trawlers but is not considered a desirable fish.

Four of six Dall porpoise stomachs from British Columbia contained only herring (Cowan, 1944). Two were empty. Two others of this species, taken by the Fish and Wildlife Service exploratory ship *John N. Cobb* in gill nets, had fed on hake (*Merluccius productus*).

All specimens identified from the stomach contents, except the demersal lantern fish and the bottom-living hake, are pelagic. Porpoises apparently select small, non-spiny prey. Two species, the anchovy and mackerel, are of significance in commercial catches. The food eaten by these dolphins and porpoises is similar to that of fur seals (*Callorhinus*), taken simultaneously in the same area. Both were feeding extensively on pelagic or demersal fish and cephalopods rarely taken by fishermen. Further study will be needed to fully understand the economic status of pelagic feeding mammals; it will probably reveal extensive utilization of relatively obscure forms of little commercial import. No evidence suggests that these mammals are exerting an undue drain on the productive capacity of the off-shore areas at the expense of valuable pelagic fishes.

SUMMARY

The hunting of dolphins and porpoises for food, oil, leather, and fertilizer is a well-developed industry in Japan. Hunting is done in the spring and autumn off Honshu, and in summer off Hokkaido up to 30 miles offshore, from 20 to 30-ton, motor-driven, harpoon vessels with a platform projecting from the bow for shooting and harpooning. Most animals are killed by shotgun but are harpooned to forestall sinking. Many more can be taken in this manner than by harpoon alone.

Striped dolphins, which congregate in herds of up to several thousand animals sometimes mixed with right-whale dolphins, are more elusive than Dall or True porpoises which are usually in groups of less than 15.

Copulation of striped dolphins was observed in March, as was a female carrying a well-developed fetus. Fetuses of both Dall and True porpoises were found in May. A series of True porpoises collected from March to May suggest that, in spring, the males are in the southern and the females in the northern parts of the range.

The range of the Dall porpoise on the Japanese coast is more northern than is

that of the True porpoise, but the ranges overlap more than 200 miles. Dall and True porpoises school separately, and no intergrading color patterns were seen. Our data do not confirm the conclusion of Benson and Groody that *truei* is a synonym of *dalli*.

Lantern fish (Scopelidae) comprised over 70 per cent of the stomach contents of the striped dolphin and True porpoise. Squids were the principal food found in Dall porpoise stomachs. Squids were taken very frequently by the other two cetaceans but made up less than one-fifth of the volume. Commercial fish species found in the stomach contents were mackerel, anchovies, and a hake-like fish *Laemonema*. Small cetaceans probably do not exert much influence on commercial fisheries.

LITERATURE CITED

Andrews, R. C. 1911. A new porpoise from Japan. Bul. Amer. Mus. Nat. Hist., 2: 31–52.

Benson, S. B., and T. C. Groody. 1942. Notes on the Dall porpoise (*Phocoenoides dalli*). Jour. Mamm., 23: 41–51.

Benson, S. B. 1946. Further notes on the Dall porpoise. Jour. Mamm., 27: 368–374.

Cowan, I. M. 1944. The Dall porpoise, *Phocoenoides dalli* (True) of the northern Pacific Ocean. Jour. Mamm., 25: 295–306.

Fraser, F. C. 1940. Three anomalous dolphins from Blacksod Bay, Ireland. Proc. Royal Irish Acad., XLV, Sec. B., No. 17, 413–455.

Higgins, E. 1919. Porpoise captured. Calif. Fish and Game, 5: 157.

Matsui, Y., and E. Noguchi. 1946. On the body length, reproduction, and migration of Dall's porpoise (*Phocoenoides dalli*) captured off the coasts of Tajima, Hyogo Prefecture. Ig. to Sci., 9: 216–218.

Matsuura, Y. 1943. Marine mammals, Tokyo, Japan. 290 p.

Naguchi, E. 1943. On the utility of the common dolphin and Dall's porpoise. Hyogo Chu Hok Zas (Natural History Magazine for Hyogo middle school education), 8, 9: 17–22.

Scheffer, V. B. 1950 The striped dolphin, *Lagenorhynchus obliquidens* Gill, 1865, on the coast of North America. Amer. Midl. Nat., 44: 750–758.

U. S. Fish and Wildlife Service, 2725 Montlake Boulevard, Seattle 2, Washington. Received September 30, 1952.

GENERAL NOTES

DOLPHIN PROTECTING DEAD YOUNG

On July 12, 1952, while in the observing tower of the San Diego County Life Guard Station at Imperial Beach, California, Life Guard Lieutenant Allan D. Holder observed, in a school of four or five, a dolphin swimming at the surface with some object held astraddle its dorsal fin. The group was moving alongshore about one-fourth mile off the long sandy beach. Perhaps 40 or 50 dolphins were sighted during the day and schools had been seen this year more frequently than usual. The one with the object draped over its fin swam at the surface like a shark, with its dorsal fin almost continuously exposed, but kept up with the others that were rolling out and submerging as usual. In order to make a closer inspection Lieut. Holder and a helper put out in a dory and gradually overtook the group. About four times the object became detached, but each time the dolphin came up under it again and continued with it at the surface. When approached closely the adult submerged and took off. When the dory was brought alongside, the object that had been carried proved to be a young, presumably newborn dolphin about four feet long, so long dead that it was largely disemboweled and quite limp. After moving off about 25 feet and resting at the oars quietly for some time, Holder saw the adult dolphin return and make off again with the dead young hung over its dorsal fin. Two and a half hours later it again passed the life guard station, carrying the young in the same way. Holder feels quite sure that the same individual was performing each time, for its dorsal fin was a little smaller than those of its companions, and it was otherwise distinctive.

Many incidents have been recounted of dolphins showing apparent care and solicitude for dead dolphins and other objects, even human corpses. In the oceanarium of Marineland, Florida, captive adults of the Atlantic bottlenose dolphin, *Tursiops truncatus* Montagu, have shown great solicitude for newborn young, dead as well as alive (McBride, Nat. Hist., 45: 29, 1940; McBride and Kritzler, Jour. Mamm., 32: 254, 1951).

An apparent effort of an adult dolphin to protect a wounded companion has been reported to me by John F. Janssen, Jr., of the California Department of Fish and Game, who kindly permits the publication of his observation. On October 8, 1939, an adult striped dolphin, *Lagenorhynchus obliquidens* Gill, was harpooned from the M. V. "N. B. Scofield" in Bahía Ballenas, Baja California, two miles offshore and 18 miles south of the west end of Holcombe Island. Another adult, thought by Mr. Janssen and party to be the mate, stayed close beside the harpooned individual, frequently forcing its way between the dying beast and the ship and pushing it away. The skull of the harpooned individual is deposited in the Museum of Vertebrate Zoology of the University of California at Berkeley (No. 95088). Photographs presented by Mr. Janssen confirm the identification cited above. *Lagenorhynchus obliquidens* and *Delphinus bairdi* True are the two common dolphins of the open sea off the coasts of California and Baja California.

The solicitous parent that was observed by Lieut. Holder was almost surely a Pacific bottlenose dolphin, *Tursiops gilli* Dall, a species extremely close to the one kept and trained at Marineland, if not identical. He said it was one of the kind that repeatedly courses along Imperial Beach. As I have recently indicated (in the note by Kenyon, Jour. Mamm., 33: 385–387, 1952), *Tursiops gilli* is the dolphin that occurs in the bays and lagoons and along the beaches, in and near the surf, in southern California and along the coasts of Baja California. I have seen thousands in such habitats, and the open-water species almost never penetrate into the inshore habitat of *Tursiops*.

I am indebted to Lieut. Holder not only for this data but also for other information regarding the marine life of his region. I feel full confidence in the accuracy of his observations and reports.—Carl L. Hubbs, *Scripps Institution of Oceanography (University of California), La Jolla, California.* *Received September 24, 1952.*

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SILVER-HAIRED BAT, *LASIONYCTERIS NOCTIVAGANS*, IN WEST VIRGINIA

Thaddeus Surber (Proc. 3rd Ann. Meeting W. Va. Fish and Game Protective Assoc., App. E, p. 55, 1909) in the first ". . . annotated list of all [mammalian] species found in the State [West Virginia]," included, without locality records, the silver-haired bat, *Lasionycteris noctivagans* (LeConte) as being ". . . more partial to the forests than the other species." Authors of several subsequent "State lists," presumably on Surber's authority, included the species. The only published record for the State is that by Wilson and Friedel (Proc. W. Va. Acad. Sci., 15: 87, 1942) reporting on a mounted bat in the Zoology Museum, West Virginia University, that was taken in 1925 by A. M. Reese at Morgantown; however, in a later paper Wilson (W. Va. Conservation, IX (12): 9, 1946) thinks that the ". . . mounted specimen in the University Museum, formerly believed to be this species, may have been misidentified." Recent (June 7, 1952) inquiry at West Virginia University revealed that the specimen in question cannot now be found.

Excluding Wilson and Friedel's Morgantown bat, I now have records of fifteen specimens of *Lasionycteris* from nine localities in West Virginia that were collected between June 5, 1950, and May 31, 1952. The first specimen was shot by W. H. Davis, on June 5, 1950, one mile NE Caldwell, 1850 feet elevation, Greenbrier County. The second one was found by James E. Shires, December 23, 1950, in his home three miles SW Huntington, 550 feet, Wayne County. Through the efforts of Nan Clark's 1952 Biology students at Guyan Valley High School, I have received alive nine silver-haired bats from Lincoln County; one was found March 2, 1952, in a blacksmith shop at Allen, 850 feet; one was caught in an abandoned chicken house, March 12, in West Hamlin, 600 feet; another was taken from a crack in a sandstone ledge two miles NE West Hamlin, 800 feet, on March 11; four specimens were found March 9 and two more were found March 11 in crevices in a sandstone ledge at Ranger, elevation 900 feet. An interesting record for *Lasionycteris* was established by Christy A. Weiland and W. H. Davis when they took a male from Greenville Saltpeter Cave (37°33 N; 80°41′ W), entrance elevation 1680 feet, Monroe County, on April 12, 1952. On May 8, 1952, W. H. Davis shot a female three miles NE Morgantown, 1100 feet, Monongalia County. Mr. Davis also killed two silver-haired bats, May 31, 1952, five and one-half miles N Upper Tract, 1220 feet, Pendleton County; these are the last specimens from West Virginia to come to my attention.

With the exception of a female from Ranger, found March 11, and the one from three miles NE Morgantown, all the silver-haired bats discussed here were males. The June 5 specimen from one mile NE Caldwell was shot as it circled over the Greenbrier River; it probably was a breeding individual. The example from three miles SW Huntington, December 23, certainly represented a wintering record; indications are that this individual may have been hibernating in the attic of the house and was aroused by a few days of unseasonably warm weather. All the Lincoln County specimens had enough food in the digestive tracts to indicate that they were not hibernating; those from the sandstone ledges at Ranger and two miles NE West Hamlin were found approximately twenty inches back in narrow (two to four inches) crevices in association with *Eptesicus fuscus fuscus* (Beauvois). The Greenville Saltpeter Cave specimen was hanging alone but near a few *Myotis* (both *M. lucifugus lucifugus* (LeConte) and *M. sodalis* Miller and Allen were collected) approximately 1000 feet back in the cave. The female from three miles NE Morgantown was killed as it flew over a farm pond; the two males from five and one-half miles N Upper Tract were shot as they circled over a picnic area on the South Branch of Potomac River. Available evidence now seems to indicate that the species is a year-round resident at least in parts of southern West Virginia. I am uncertain whether silver-haired bats are now more abundant in this area or whether collecting opportunities have been more fortuitous.

Average and extreme external measurements (millimeters) and weights (grams) of nine adult male silver-haired bats, prepared by me, from Greenbrier and Lincoln Counties: length, 99 (90–103); tail, 41 (38–43); foot, 9.9 (9–10); ear, 15.6 (15–16); weight, 8.1 (7.0–9.1); forearm (dry), 40.6 (39.7–42.0); one female measured 108 x 46 x 10 x 16 = 9.2; forearm, 41.5.

The study skins and skulls of the specimen from one mile NE Caldwell and one of the specimens from five and one-half miles N Upper Tract are in W. H. Davis' collection; the others are in my possession.—W. Gene Frum, *328 Tenth Avenue, Huntington, West Virginia. Received September 3, 1952.*

TWO ERYTHRISTIC RACCOONS FROM FLORIDA

Two erythristic raccoons, *Procyon lotor elucus*, were collected in the summer of 1951 by Mr. Lamont Pharmer. They were found near Black Sink Prairie, about three miles southeast of Citra, Marion County, Florida.

The two were of similar coloration. The back was dull orange-red (close to 3 A 11 in Maerz and Paul, dictionary of color, 2nd ed.), fading to ivory (close to 10 B 1) on the sides and belly. The facial mask was burnt umber (close to 15 A 12), outlined with ivory. The tail rings were golden brown (close to 14 C 12). The nose was approximately burnt umber. The specimens were brought to me as fresh skins; eye color was not noted. The animals, both half-grown, were found together. Doubtless they were of the same litter.—Wilfred T. Neill, *Research Division, Ross Allen Reptile Institute, Silver Springs, Florida. Received October 10, 1952.*

FALL FOOD HABITS OF THE RACCOON IN THE SOUTH PLATTE VALLEY OF NORTHEASTERN COLORADO

In northeastern Colorado raccoons are increasing rapidly, and in recent years they have caused some damage to poultry and farm crops. This factor, particularly, led to the present study of the food habits of the raccoon in the region indicated. Similar studies have been made in other regions, chiefly in the Midwest and East; but there appears to be no previous study of food habits of raccoons (*Procyon lotor*) in irrigated riverbottom lands such as are found on the high plains of various western states.

A total of 97 scats and three digestive tracts were analyzed; all were collected during November and December, 1951, in Sedgewick, Morgan, Weld, and Larimer counties of northeastern Colorado. The scats were found in a number of places, but for the most part were picked up along rivers and streams or near reservoirs. Often large logs or rocks served as defecation sites, and frequently yielded several scats. In Morgan County, a number of samples were found on the higher ledges of bluffs along the South Platte River. The three stomachs and intestinal tracts were taken from raccoons killed on a hunt in Morgan County.

In this study the volume and frequency of each food item was determined. Dried scats were broken up and individual items in each measured in a graduated cylinder under uniform pressure. Quantities less than 0.1 per cent of the total were listed as traces.

Plant material constituted 73, and animal foods 27 per cent, of the scat contents during the period studied (Table 1). Two animal and four plant foods, each constituting 3.0 per cent or more of the total fecal bulk, made up 92.7 per cent of the total volume.

Corn is a highly preferred raccoon food in other sections of the United States, as is well known, and constituted over half of the total food volume studied in northeastern Colorado. Farmers in this area often leave corn standing in the field, thus providing choice food for raccoons until well into the fall. The high frequency of corn (82.5 per cent) indicates that they definitely sought cornfields for feeding.

Plums, cherries, and grapes were the only other plant foods that occurred in the diet in quantities larger than one per cent by volume. Wild plums and grapes were common in most of the riverbottom areas where fecal collections were made, and domestic cherry orchards were abundant in Larimer County.

Unidentified grasses and seeds constituted but a small part of the total food volume. The relatively high frequency of Russian thistle, compared with its small volume in the diet, seems to indicate that it was ingested accidentally while feeding on some other food, probably grasshoppers or other insects.

Insects made up 13.1 per cent of the total volume of food, grasshoppers being most important. Small quantities of beetles and other unidentified insects were found in nine scats.

Crayfish showed a frequency of occurrence more than twice as high as for grasshoppers, but their total volume was slightly smaller than that for grasshoppers. The only aquatic foods, other than crayfish, were snails and fish. Snails (*Physa* sp.) were found in small amounts in four scats; one dropping contained several scales and bones from a carp.

Small mammal remains were found in ten scats and made up two per cent of the total volume. Six of these ten scats contained rabbit fur or bones, three contained fur from the western pocket gopher, *Thomomys* sp., and one contained hair from a meadow mouse,

TABLE 1.—*Fall foods of raccoons in northeastern Colorado, 1951 (based on 97 scats)*

	FREQUENCY	% OCCURRENCE	VOLUME (CC.)	% VOLUME	
Animal Foods					
Crayfish	43	44.3	677.9	9.8	
Snails	4	4.1	2.5	tr.	
Fish	1	1.0	2.0	tr.	
Birds—unidentified	17	17.5	68.6	1.0	
Ring-necked pheasant	1	1.0	78.0	1.1	
Egg shells	1	1.0	tr.	tr.	
Small mammals	10	10.3	137.0	2.0	
Insects—unidentified	6	6.2	48.5	0.7	
Grasshoppers	20	20.6	855.5	12.4	
Beetles	3	3.1	2.0	tr.	
Sub-total					27.0
Plant Foods					
Corn	80	82.5	3963.2	57.2	
Plums	18	18.6	475.0	6.9	
Cherries	5	5.2	206.0	3.0	
Grapes	4	4.1	233.5	3.4	
Seeds—unidentified	3	3.1	48.0	0.7	
Grass	3	3.1	13.0	0.2	
Russian thistle	5	5.2	tr.	tr.	
Sub-total					71.4
Detritus					
Sand, stones, and soil	9	9.3	110.5	1.6	
Twigs	1	1.0	2.0	tr.	
Sub-total					1.6
Total					100.0

Microtus sp. Eighteen scats contained remains of birds, but the volume of all such items was only 2.1 per cent. Positive identification of feathers was possible in only one scat. This dropping contained 78.0 cc. of ring-necked pheasant feathers and bones. Collection was after the pheasant hunting season, suggesting that this bird may have been a cripple or unretrieved kill. Bits of egg shell were found in one scat.

A range of one to seven food items was found in each scat, the average being 2.6. The average scat size was 71.4 cc.

The three digestive tracts collected during this investigation were all taken from ani-

mals killed the same night and in a small area. The stomach of the adult female contained 5 cc. of unidentifiable, green, plant material; the small intestine was empty, and the large intestine contained 144 cc. of corn. The two immature raccoons, one male and one female, had empty stomachs and small intestines, but the large intestines contained 110 cc. and 97 cc. of corn, respectively.

It is impossible to determine from the 100 samples studied how much of the corn consumed was waste, *i.e.*, grain left on the ground after harvest.—JOHN R. TESTER, *Colorado Cooperative Wildlife Research Unit, Colorado A & M College, Fort Collins.* *Received October 25, 1952.*

FORMATION OF URINATING "POSTS" BY HOUSE MICE (*MUS*) HELD UNDER RESTRICTED CONDITIONS

An unusual condition has been observed in a densely populated colony of house mice (*Mus*) maintained at the Wildlife Research Laboratory, Denver, Colorado. A rodent-proof room with dimensions of about 14 x 20 feet was established in the spring of 1950 to determine the efficacy of repellent compounds applied to packaging and other materials. In the room is a wide variety of food stuffs in bags and boxes on which the animals subsist.

Although nesting facilities were provided at the outset, the mice (approximately 75 animals) soon established living quarters in the containers from which food had been removed.

PLATE I

UPPER. A close-up view of mouse urinating "posts" formed at intervals of about 3 inches. LOWER. Note alignment of "posts" on storage platform.

It was noted early that droppings deposited on boxes and other undisturbed surfaces were being used as urinating posts which, with the accumulation of dust and debris, grew to considerable size (Pl. I). The colony has been in existance approximately two years and the largest of these deposits is about 1½+ inches high, 1 inch wide at the top with a ¾ inch base. Normally, however, they are about 1 inch high and ⅜ inch in diameter. In shape they resemble miniature rock formations such as are found in Southeastern Utah in the "Valley of the Goblins".

The distribution pattern of the "posts", where undisturbed, shows some symmetry as illustrated. Their density in some places is 50–60 per square foot. On boxes and bags placed in the room for shorter periods more thread-like columns have been formed. Of particular interest was a series of posts which appeared on a sack of flour placed on the floor of the room. Here the mice established a trail of posts lengthwise across the top of the sack, each being about ¾ inch high spaced at quite regular intervals of about two inches.

Attempts have been made to determine the manner in which the deposits are made. Millard Graham, Laboratory Assistant, reports seeing mice mount them but it is not known if this is common to both sexes or not. Food containing two per cent of methylene blue as a tracer was made available to the animals. Subsequent observations revealed blue colored urine deposits on most of the posts located in the vicinity of the colored food dishes. Disintegration of different sections of these deposits by soaking them in water overnight revealed that, except for the base, they consist of debris cemented together by urine. The base is made up of feces which presumably serves as a starting point.

Population density, coupled with the fact that the animals are confined to a limited space may contribute to this phenomenon. No mammalogists or rodent control specialists visiting the Laboratory have observed such deposits elsewhere.—Jack F. Welch, *Wildlife Research Laboratory, Fish and Wildlife Service, U.S.D.I., Denver, Colorado.* *Received September 8, 1952.*

A TECHNIQUE FOR FINDING *MICROTUS* NESTS

Nicholson (1941) and Howard (1949) studied nesting habits and dispersal in *Peromyscus* spp. by means of nest boxes. This method proved unsuccessful for *Microtus agrestis* L., and a new method, which consisted of labelling pregnant females with radioactive material, was developed for finding nests containing young. This work was carried out during 1951 on the Oxford University estate at Wytham, Berkshire.

Females captured in "Longworth" live-traps were palpated, using the technique developed by Ranson (1941), and the number and estimated ages of the embryos was recorded. Leg-rings containing approximately 100 μc of radioactive Cobalt (Co 60) were fitted to the hind legs of the pregnant females with modified pliers, and the animals were then released (Godfrey, in press). Females carrying radioactive rings were located daily with a portable Geiger-Müller counter unit, and in the places where they were recorded a search was made for nests. Eighty-five nests were found between May and September 1951, of which 32 contained young.

Nests with young were found more easily during the first four days after birth than towards the end of lactation. Twenty individuals bearing radioactive rings were in their nests during the first four days after parturition on 23/33 (69.9%) of the occasions on which their positions were recorded, whereas during the 9th–12th day, they were in their nests on only 9/36 (25.0%) of the occasions (Table 1). The time spent away from the nest clearly increased throughout lactation.

Nearly all the nests found between May and September had been built above the ground in a slight excavation in the soil (Davis, 1934). Two were partly underground in vertical burrows. Although the nests were often built beneath tussocks of *Brachypodium pinnatum* L., (the dominant species of grass), they were also found where there was less cover. Thus one nest examined in early May had been built beneath the aerial roots of *Arrhenatherum elatius* L.) J. & C. Pressl, whose shoot had not yet begun its new season's growth.

The nests were globular in shape and consisted chiefly of finely-shredded dry grass, though strands of fresh grass were sometimes incorporated in the outer layers. They had no obvious entrance and the runs leading up to them were often indistinct, perhaps because each nest was used for a relatively short period.

When nests containing young were examined, the females usually transferred their litters to other nests. Their reaction to disturbance varied, however, and some individuals moved their young as many as three times in twelve days, while under the same conditions, others did not move them at all. One female shifted her litter three times in the first eight days, finally carrying it into a nest box where it remained in spite of further disturbance. Hamilton (1937) reports that in *Microtus pennsylvanicus* the female invariably moves the young to another nest following disturbance.

Quantitative information on rates of resorption could not be obtained as the litters could not always be found immediately after they were born. In two out of nine litters which were found shortly after birth fewer young were born than had been diagnosed, and the missing embryos are assumed to have been resorbed or still-born (Table 2). Ranson (1941) shows that litters in which fewer young are born than palpated may be assumed to have suffered

TABLE 1.—*Frequency with which nests found contained young*

Day of lactation	1	2	3	4	5	6	7	8	9	10	11	12	13	14
No. nests found	9	4	5	5	4	1	5	6	3	2	2	2	0	0
Total recordings	10	8	7	8	9	7	11	9	10	8	8	10	6	7
% recordings in which nests were found	69.9				44.4				25.0					

TABLE 2.—*Number and estimated age of embryos obtained by palpating nine pregnant voles*

No. embryos palpated	4	3	4	6	2	3	2	4	2
No. embryos born	3	6	3	6	3	4	4	4	3
Error	+1	−3	+1	0	−1	−1	−2	0	−1
Est. age in days of embryos when palpated	12	12	13	15	16	16	16	17	18
Actual age when palpated (assuming gestation = 21 days)	13	11	15	17	18	17	17	18	17

resorption, because although embryos are missed occasionally during counting, it is almost impossible to count more than there really are.

This table gives some idea of the personal error involved in palpation, and shows that while the ages of the embryos were assessed with considerable accuracy (the gestation period according to Ranson is 21 days), the numbers present were frequently underestimated.

It was difficult to obtain information on nestling mortality as the young were capable of leaving the nest when a week old and tended to do so as soon as it was disturbed. Nevertheless, one young vole in a litter of three was known to have been lost between the 4th and 10th day after birth, and it is extremely unlikely that any of the young survived in two of the three litters which were examined just before they left the nest. These did not increase in weight after the first week when they weighed approximately 4.5 gm. each, so that on the 12th day they were considerably below the 6–7 gm. typical of fully-grown nestlings in Wytham. They had increased in size but they were very weak and their eyes were still closed. These observations will be discussed in another paper. According to Chitty (1952), in Wales the young first enter traps at a slightly higher body weight; the adults are on an average heavier than those in Wytham.

The young were normally weaned between 12–16 days of age. It is not known whether

they left the nest of their own accord or were driven out. The nests were usually falling apart at this stage, and even if they had not been disturbed, it is unlikely that they would have been used for another litter. In one case, however, a female did move her young into a nest she had used for a previous litter.

There was no evidence that the young dispersed far from their places of birth. A female, which was ringed with a radioactive ring when 12 days old and was located 18 times during the next two months, was never recorded further than 20 yd. from the nest in which it was born. Thirteen voles, which were first trapped when they weighed 5–8 gm., and were recaptured before they were sexually mature, were caught not more than 25 yd. from their original positions. Of 21 voles which were still immature when first trapped, but were mature when recaptured, only one was taken more than 30 yd. from its original position. Large-scale movements, either at weaning or at sexual maturity, were evidently rare.

LITERATURE CITED

CHITTY, D. 1952. Mortality among voles (*Microtus agrestis*) at Lake Vyrnwy, Montgomeryshire in 1936–39. Philos. Trans. B, 236: 505–552.

DAVIS, D. H. S. 1934. A preliminary survey of the nest fauna of short-tailed voles (*Microtus agrestis* and *M. hirtus*). Ent. Mon. Mag., 70: 96–101.

GODFREY, G. K. (In press) Tracing field voles (*Microtus agrestis* L.) with a Geiger-Müller counter.

HAMILTON, W. J., JR. 1937. Growth and life span of the field mouse. Amer. Nat., 71: 500–507.

HOWARD, W. 1949. Dispersal, amount of inbreeding, and longevity in a local population of prairie deermice on the George Reserve, southern Michigan. Contr. Lab. Vertebrate Biol. Univ. Mich., 43: 1–50.

NICHOLSON, A. J. 1941. The homes and social habits of the woodmouse (*Peromyscus leucopus noveboracensis*) in southern Michigan. Amer. Midl. Nat., 25: 196–223.

RANSON, R. M. 1941. Pre-natal and infant mortality in a laboratory population of voles (*Microtus agrestis*). Proc. Zool. Soc. Lond. A, 111: 45–57.

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Received May 1, 1953.

USE OF NEST BOXES IN WOOD MOUSE POPULATION STUDIES

Artificial nest boxes were found to provide a convenient means of studying small mammal populations by Nicholson (Amer. Midl. Nat., 25: 196–223, 1941), who used small, nearly cubical boxes in his investigations of *Peromyscus* populations. This method was attempted in a study of the reproduction and behavior of the wood mouse (*Peromyscus leucopus noveboracensis*) in southern New Jersey (Jackson, Ecol. Mono., 22: 259–281, 1952); but when the initial efforts produced comparatively few data, intensive observations were halted. Sporadic observations were made during the course of other field work, and the data gathered from July, 1950, to January, 1952, are presented here.

The nest boxes, constructed with ½ inch yellow pine lumber, had inside dimensions of 4.5 x 4 x 4 inches. The tops, held loosely by two nails inserted into holes in the sides, could easily be lifted up for purposes of observation. A single, inch square, floor level opening was located at the back next to the tree trunk. The boxes lacked slide covers over the entrance, an inner screen below the roof, and paint or preservative as employed by Nicholson.

In June and July, 1950, 44 boxes were placed in the edges of two oak woods, each about 50 acres in size. Placed on tree trunks five feet above the ground, the boxes were about forty feet apart, and 10–25 feet from the edge of a cultivated field or an orchard. The woods, dominated by white oak (*Quercus alba*) and scarlet oak (*Q. coccinea*), had sevéral other oak species and some cherry (*Prunus serotina* and *P. virginiana*).

Initially, cotton batting was placed in the boxes, and during subsequent visits more was added if the original supply had been removed. Only day-time observations were made and

consisted of individually marking, by toe clipping, any mice present, recording their approximate weight, noting their pelage and general reproductive condition, and checking the condition of the nest. The marked mice were released in the nest box where they sometimes remained or, more often, quickly made their way to the ground and found refuge in a hole.

Most of the mice made use of the cotton supply and constructed nests almost wholly of cotton. Typically, the cotton was shredded and formed into a hollow sphere, nearly filling the nest box; generally the nest entrance was near that of the box. Of 52 nests examined, 39 (75.0%) were constructed of cotton batting; 5 (9.7%), of leaves and cotton; 2 (3.8%), of leaves and feathers; 3 (5.8%), of moss and leaves; and 1 each (1.9%), of red cedar bark (*Juniperus virginiana*), chicken feathers, and leaves, paper, and hair. When mice moved in following an avian occupancy, the new nest was built on top of or beside the bird nest. This globular-type nest served as a sleeping nest; no food was stored, and only scattered shells and fecal pellets were evident. Though there was often a corner of urine concentration, the nests did not become foul and damp as described by Nicholson (*loc. cit.*). Probably the less intensive use of the nests in the present case is an adequate explanation of this.

TABLE 1.—*Summary of nest box inhabitations*

DATES OF OBSERVATIONS	1950					1951					1952	TOTAL
	July 20	Aug. 14	Sept. 2	Oct. 27	Nov. 15	Jan. 28	May 15	June 13	July 20	Oct. 1	Jan. 4	
No boxes inhabitable	44	42	42	42	42	41	35	31	37	37	25	—
No. nests with mice	3	10	9	9	5	0	5	2	1	11	3	—
Boxes inhabited, %	6.8	23.8	21.4	21.4	11.9	—	14.3	6.5	2.7	29.8	12.0	—
No. platform nests	0	0	4	12	11	7	6	10	9	6	4	—
No. mice caught	3	13	11	24	7	0	5	3	1	14	6	87

The platform-type nest, in contrast, served as a feeding station. Here the cotton, rather than being fluffed in a ball, was flattened into a mat-like structure on the floor. Although there was no storage of food, ample evidence of feeding was present. Opened acorns and cherry pits, empty pupal cases, and fecal pellets littered the floor. Cherry pits, opened along their equator and thus leaving empty hemispheres, were the most prevalent. In 14 cases platform nests were found subsequent to the occupancy of a spherical nest, suggesting that the platform is a trampled down globular nest. However, in nine cases a spherical nest was found after a platform, suggesting the process could be reversible.

Considerable seasonable variation in the occupancy rate of the houses occurred (Table 1). Part of the variation resulted from some of the boxes being uninhabitable for the mice for a period of time. Some vandalism occurred; tops were lifted off and whole units were ripped off the tree trunks, thus temporarily reducing the number of habitable boxes. At other times nests of other mammals, birds, or insects also reduced the number of available houses, for no attempt was made to purge these other animals.

The inhabitation prevalence varied in addition to this. During the spring and early summer when the population density was low, fewer mice were observed; but correlated with the maturation of the first litters and the development of the later ones, the percentage of inhabited boxes rose sharply during the late summer and early fall. Two midwinter observations indicated the downward trend to be in progress.

That wood mice live alone is indicated by observations of 60 inhabited nests in which single mice were found 41 times; pairs of mice, 12; and other groupings, 7. During both breed-

ing and non-breeding seasons, pairs of mice were found. In three cases, immature females (grey pelage, vaginal orifice imperforate) and in two other cases submature females (transition pelage, vaginal orifice perforate) were found with mature males (brown pelage), a pattern also found by Nicholson (*loc. cit*). While no very young mice, indicating probable birth in the box, were found, one near-term female was marked on August 14, and was found in the same box on September 2 with young several weeks old. While the sexes of the immature mice were approximately equal (10 ♂♂, 17 ♀♀), the relative numbers of the sexually mature mice (32 ♂♂, 19 ♀♀) reflects the tendency of the males to wander more and thus be caught more.

Shifting of nests sites was very frequent. In only two cases were mice found in the same box on two successive observations: one, an interval of 19 days; the other, 42 days. Nicholson found the same pattern and believed the disturbance caused by handling the mice was only a minor factor in this frequent change of residence. Of the 75 mice marked, only eight were recaptured a second time; and none of these had moved more than two stations (80 feet) from their point of original capture.

Numerous other forms of animal life inhabited these boxes. A pair of flying squirrels (*Glaucomys volans*) enlarged both the box opening and the deserted, cotton mouse nest. Two colonies of bumble bees (*Bombus* sp.) established themselves in the spring and thrived all summer; but in the fall, the bees disappeared and the nests were raided of their contents. Presumably mice took advantage of the situation for many fecal pellets were in the boxes. House wren (*Troglodytes aedon*) nests were started in seven boxes and three broods fledged from two nests. The other nests were either never finished or were deserted early in incubation for unknown reasons.

Many invertebrates lived in the boxes with the mice. Wood roaches (*Parcoblatta pennsylvanica*) occurred in most boxes. Although it is known from stomach analyses that wood mice will eat wood roaches (Jackson, *loc. cit.*), there was no evidence here of interference between these two species. Hornets (*Vespa* sp.) built nests from the ceiling in boxes both occupied and deserted by mice; spiders and their webs frequently were located also in the tops of boxes. In neither case were there evidences of conflict with the mice. Clusters of carpenter ants (*Camponotus* sp.) and nididulid beetles were found in several boxes containing deserted mouse nests.

Acknowledgements.—Dr. David E. Davis has been of constant help during these studies. Dr. C. W. Thornthwaite of the Johns Hopkins Laboratory of Climatology, Seabrook, N. J., and the Seabrook Farms staff were most generous in giving of their time, facilities, and advice.—William B. Jackson, *Division of Vertebrate Ecology, The Johns Hopkins University, Baltimore, Maryland.* *Received September 4, 1952.*

TRANSMIGRATION OF FERTILIZED EGGS IN *PEROMYSCUS*

In mammals, most of the ova are shed into the funnel of the oviduct and are fertilized in the upper portion of the latter. They then descend to the uterus of the same side and implant there. Occasionally an ovum from one ovary may be fertilized and transported to the uterine horn of the opposite side. The occurrence of this phenomenon, here called transmigration, is doubtless often masked by the impossibility of associating any given embryo with its respective corpus luteum. Nevertheless, during the routine examination of near-term, laboratory-bred, female deermice of the genus *Peromyscus*, several probable cases of transmigration were observed.

Out of 355 gravid *Peromyscus* females examined, five possible cases of transmigration of fertilized ova were found in them. In five matings of *Peromyscus polionotus leucocephalus*, one female was obtained in which the number of embryos in the left uterine horn was greater than the number of corpora lutea in the ovary of the same side. This could have been due to the migration of a fertilized egg from the right to the left uterine horn, but it might be explained as well by polyembryony or polyovulation. However, in three other instances (two cases in matings of *P. maniculatus blandus*, and one in a mating of F_1 hybrids of ♀ *blandus* × ♂ *bairdi*), all of the right ovaries lacked corpora lutea, while the right uterine

horn contained either one or two embryos. In these cases, the possibility of polyembryony or polyovulation does not provide an explanation. It is probable that they resulted from the left to right transmigration of fertilized eggs. In still another case, found in the cross mating of ♀ *blandus* × ♂ *bairdi*, the female had two normal fetuses in the left uterine horn and one partially resorbed embryo in the left mesometrium, but only two corpora lutea were observed in the left ovary. This extra embryo may have been the result of polyembryony or polyovulation, or it might be that the partially resorbed embryo in the mesometrium was a remnant from a previous pregnancy. This extra-uterine embryo, however, offers direct evidence that fertilized eggs sometimes fall into the peritoneal cavity.

It has been shown in domestic animals that if an ovary is removed but the funnel and the oviduct of the same side are left intact and the other oviduct is closed, a normal pregnancy can follow. The ovum must therefore be liberated from one ovary, cross the intervening space in the peritoneal cavity, and pass down the uterine horn of the other side (Dukes, THE PHYSIOLOGY OF DOMESTIC ANIMALS, 1943). Brambell (Proc. Zool. Soc. London, 114: 1–45, 1944) reported that such transperitoneal migrations have occurred in the wild rabbit, *Oryctolagus cuniculus*. Sometimes, however, the blastocyst is known to pass from one uterine horn to that of the opposite side through the corpus uteri. Warwick (1926, cited from Dukes, *op. cit.*) has shown that this occurs in semi-spayed sows. Hall and Davis (Texas Rpts. on Biol. and Med., 8: 564–582, 1950) have stated that the transmigration of fertilized ova is unlikely to occur in the rat, due to the anatomical structure of the female reproductive system, but no physical obstacle has been detected in the corpus uteri of *Peromyscus*.

In summary, several cases in which *Peromyscus* embryos have been found in a uterine horn without corresponding corpora lutea in the ovary of that side cannot be explained by either polyembryony or polyovulation. The most reasonable explanation of these cases is that fertilized ova have migrated from one side of the body to the other. A partially resorbed embryo found in the mesometrium gives evidence that a fertilized ovum could cross through the peritoneal cavity from an ovary to the opposite uterine horn. The transmission of blastocysts through the corpus uteri also appears to be possible in *Peromyscus*.—T. T. LIU, *Institute of Human Biology, University of Michigan, Ann Arbor. Received September 22, 1952.*

IS *SIGMODON AUSTERULUS* A VALID SPECIES?

Bangs (Bul. Mus. Comp. Zool., Harvard Univ., 39, 1902) described *Sigmodon austerulus* from a single specimen taken by W. W. Brown, Jr. "from the top of the Volcan de Chiriqui." This he did partly on the basis of ". . . a more hispid pelage . . . paler coloration . . . longer tail" than *S. borucae* and partly because Mr. Brown did not find any specimens of *Sigmodon* in the forested areas lying between the lowlands and the top of the old volcan. We spent weeks on top of El Volcan de Chiriqui trying to take this animal. We secured large series of *Reithrodontomys creper* and *R. australis vulcanius* and *Scotinomys xerampelinus* on the level floor of an old crater at an elevation of approximately 10,600 feet. We took *Peromycus nudipes* and *Oryzomys devius* in the wooded surroundings. But we did not capture any *Sigmodon*. Fire has burned out the "Potrero", as it is known locally, several times so we blamed our failure on fire. We have collected long enough to know that it is foolhardy, as well as unscientific, to assume that an animal is not present unless we take it, but the reason for our failure was given when Henriquito D'Arcy visited the "Potrero." D'Arcy worked with W. W. Brown, Jr., and has worked since as a collector of birds and mammals. His knowledge of the fauna is astounding and the accuracy of his observations a constant source of wonder to the mammalogist. When he visited the "Potrero" we showed him our collection and spoke of our failure to take *Sigmodon* and *Syntheosciurus*. Pointing to a patch of grass in the northwest part of the old crater he said: "That is where *Sigmodon* was caught." We had trapped the area for several weeks and told him so. Then he said he thought he understood our failure. The *Sigmodon* described by Bangs was taken by a native helper of Brown's one morning after his return from a trip to his home in the lowlands near Boruca,

and after Brown had promised a bottle of wine to any man who captured a *Sigmodon* at that altitude. While it may seem almost frivolous to reach a decision in taxonomy on this basis I feel that the name *Sigmodon austerulus* should properly be considered as a synonym of *Sigmodon borucae*.—Robert K. Enders, *Department of Biology, Swarthmore College, Swarthmore, Pennsylvania. Received September 3, 1952.*

THE TYPE LOCALITY OF *SYNTHEOSCIURUS BROCHUS*

The type locality of *Syntheosciurus brochus* is given by Bangs (Bul. Mus. Comp. Zool., Harvard Univ., 39: 25, 1902) as Boquete. The inference is that this species came from El Volcan de Chiriqui. This is not the case, for as Bangs says, "It is unknown to the native hunters." When we asked Henriquito D'Arcy, collector for W. W. Brown, about this rare squirrel he said that the two specimens from which the genus was described were taken on the Cordillera not on the Volcan. To prove his contention he went to the Cordillera and collected the squirrel. All together we have spent over 12 months collecting on the Volcan without seeing *Syntheosciurus*. But later we collected on the Atlantic slope of the Cordillera making observations on the life history of this unique animal as well as collecting a series. Therefore, using our own observations and D'Arcy's memory and knowledge, we recommend, without hesitation, placing the type locality on the Cordillera about 8 miles north of Boquete and not at Boquete which is on the lower slopes of El Volcan de Chiriqui.—Robert K. Enders, *Department of Biology, Swarthmore College, Swarthmore, Pennsylvania. Received September 3, 1952.*

GREY SQUIRRELS BORN AND RAISED IN CAPTIVITY

The present account of how a litter of grey squirrels (*Sciurus carolinensis carolinensis*) was born and raised in captivity is considered of interest as published accounts on this subject, other than that by Shorten (Proc. Zool. Soc. London, 121, pt. II, Aug., 1951) appear to be few. Shorten describes two litters born to squirrels after some years in captivity. The mother of the litter described below was running wild until captured in a box trap two weeks before delivery. During this period, she was submitted to a number of minor procedures including bleeding and etherization. Palpation under anaesthesia revealed the presence of large embryos. Accordingly a wad of cotton was placed in her cage. This cage had a wire bottom and measured 9 x 9 x 15 inches. Wild squirrels make little attempt to get out of such small cages and appear quieter than in larger ones. On August 1, 1952, when the squirrel gave birth to two young ones, it was decided to interfere with her as little as possible. Accordingly the young were not handled or the nest interfered with in any way for 26 days, during which time the cage was not cleaned. Usually it was difficult to catch a glimpse of the young. Within two weeks, they were fairly active and made an odd assortment of squeaks. On August 20th hair first became apparent on their bodies.

Although offered a variety of foods, the mother fed largely on sweet potatoes, raw peanuts, and black walnuts when available. She would immediately seize cicadas or grasshoppers placed in her cage and eat them avidly. Raw rabbit meat was also eaten. As I noticed that a mother squirrel in my garden gnawed old bones almost daily, I placed a ham bone in the cage. The mother gnawed it, either to wear her teeth down or, as I suspect from watching feral squirrels, for the salt and minerals present, for the bone meal chiseled off is all consumed.

On August 26, 3½ weeks after birth, the small squirrel cage was placed inside a larger one and fresh cotton provided. The mother built a new nest and transferred the young. On September 16, 6½ weeks after birth, the two young ones were removed. Both were females and both weighed 130 grams. One of the young was then successfully raised as a pet on homogenized cow's milk and Pablum administered with a dropper every three or four hours by day, none being given at night. The other squirrel was left with the mother. This squirrel weighed 170 gms. on September 24 and 208 gms. on September 30th, at which time it measured 335 mm. in total length. On this latter date it was removed from the mother to be reared separately.

Addendum.—In the late winter and early spring of 1953 eight more pregnant squirrels were obtained from the vicinity of Bethesda, Maryland. All of them gave birth and raised a total of 17 young ones under conditions similar to those described above, except that the young ones were handled frequently in the course of experimental work. The mother squirrels appeared quite tolerant of this interference.—LAWRENCE KILHAM, *Department of Health, Education, and Welfare, Public Health Service, National Microbiological Institute, National Institutes of Health, Bethesda, Maryland.* *Received October 29, 1952.*

DISTRIBUTION OF *CITELLUS TRIDECEMLINEATUS* IN ILLINOIS

In areas of northern Illinois the 13-lined ground squirrel occurs in great abundance, but in the southern one-third of the state this squirrel appears to be almost entirely absent. Carl O. Mohr (Trans. Ill. Acad. Sci. 36: 177–178, 1943) has noted sight records of *Citellus t. tridecemlineatus* in Madison, Macoupin, Greene, Pike, Sangamon, Christian, Shelby, Cumberland, Clark, and all counties north of these listed with the exception of Jersey, Calhoun, and Scott counties. The southernmost extent of this squirrel for which specimens are known to exist are Champaign and Piatt counties (Univ. of Ill., Mus. of Nat. Hist.), Macon County (R. M. Wetzel, Trans. Ill. Acad. Sci. 40: 228–233, 1947), and Sangamon County (Ill. State Mus., Springfield). Additional, well verified reports, add Montgomery County (Litchfield and Hillsboro) to the list of counties for sight records.

If the Mohr records and the additional records for Montgomery County noted above are compared to a soil association map of Illinois (Univ. of Ill. Agric. Expt. Sta., May, 1949), it will be seen that these squirrels occur predominantly on medium or dark colored soils and not on light colored soil.

The most notable exception to this observation occurs in Jo Daviess County in the extreme northwestern corner of the state. Mohr notes seven occurrences of *Citellus t. tridecemlineatus* in Jo Daviess County. It might also be observed that Jo Daviess County borders an extremely high concentration of this ground squirrel and population pressures might very well be the main cause for the occurrence of this animal in that area.—ROBERT B. CHIASSON, *Department of Zoology, University of Arizona, Tucson.* *Received September 26, 1952.*

THE CHIPMUNK AS A PREDATOR OF THE ADULT YELLOW SWALLOWTAIL BUTTERFLY

During a visit to Lake Buel in Berkshire County, Massachusetts, on June 9, 1952, I found a seepage spot on the west shore of the lake where swallowtail butterflies (*Papilio glaucus* Linn.) were congregating on a small mud flat about two feet in diameter. A closer examination revealed that the area was littered with wings of this species. The majority of these were untorn despite the fact that the butterfly bodies were missing. Most of the wings were scattered over an area of about five feet in diameter; three wings were later found fifteen feet from the area of greatest concentration. It was evident that some of the destruction had occurred a short time before my arrival since some of the wings were not yet adhering to the mud surface where they had been dropped.

Choosing a place of observation about forty yards from the landing site, I had a clear view of the area with 7 x 50 binoculars. Within ten minutes seven butterflies had returned to the spot where they had been resting prior to my arrival. Shortly after the last of the butterflies had landed, a chipmunk (*Tamias striatus lysteri* Richardson) emerged from under a building near the butterflies and stood erect for several seconds peering over the top of the grass separating him from the butterflies. He then dropped to all fours and scampered through the grass and came to a stop on the mud flat about one foot from the butterflies. Oddly enough his sudden arrival did not startle them, although he was not concealed in any way. After a brief pause, he pounced on the concentration of butterflies and pinned one to the ground with his flattened forepaws.

Once the insect had been secured, he sat up and deftly bit off each wing at the base. The body was then manipulated in such a way that the abdomen was uppermost and while in

this position it was quickly consumed. The head and thorax, with the legs still attached were dropped, and the animal apparently lost interest in further feeding and wandered off. I waited several minutes during which time the animal made no attempt to return to the insect.

A careful count of all wings which were more than half intact, revealed 142 individual wings, all from the same species. It was, therefore assumed that at least 35 adult butterflies had been destroyed in a similar manner. Many wings were water soaked and pressed on the surface of the mud, indicating that this type of feeding had been going on for some time prior to its discovery.

There appeared to be an abundance of chipmunks in the general vicinity, although only one was actually seen in the immediate area of the butterfly landing site. Many of the animals observed in the surrounding territory were carrying material in their cheek pouches, indicating that the food supply was quite abundant.—WILLIAM A. MORRIS, *Department of Forestry & Wildlife, University of Massachusetts, Amherst, Mass. Received Septemer 8, 1952.*

TROUT ENCOUNTERS PORCUPINE

On August 17, 1952, Stephen Kilian of Lakewood, Colorado was fishing on the North Fork of the South Platte River below Foxton, Colorado. Among the day's catch was a modest 8-inch rainbow which outwardly had the general healthy appearance of several others in the creel. On cleaning the fish, however, Kilian was startled to find five short porcupine quills completely embedded in the flesh of the back about midway from head to tail and all were directed vertically through the body. The tips of two of the quills had reached the skin of the back adjacent to the dorsal fin. It would appear that they had entered the body on the ventral surface and had forced their way upwardly. That the quills had been in the body for some time was evident from the congested condition of the flesh surrounding the shafts of some of them.

One can only conjecture as to what had happened to produce this unusual situation. Porcupines are fond of prowling along streams during the summer and it is not uncommon to find one wading or even swimming across narrow streams. It is conceivable that the tuft of terminal hairs of the porcupine's tail may have served as a lure and when struck by the hungry trout a responsive whip of the tail ended that episode. The final chapter was written when the trout, apparently not hampered by the barbed stilettoes, fell to the lure of the fisherman's fly.—E. R. KALMBACH, *Fish and Wildlife Service, Denver, Colorado. Received September 8, 1952.*

A RECORD OF THE PORCUPINE (*ERETHIZON DORSATUM*) FROM SONORA, MEXICO

There are a considerable number of records of the porcupine (*Erethizon dorsatum*) from outside the range and habitat thought to be normal for the species. Some of these are probably the result of transportation by humans and subsequent release or escape. Other records indicate a tendency for some individuals to wander long distances from their normal range, or even to escape general notice in regions permanently but sparsely inhabited. Taylor (Univ. Arizona Biol. Sci. Bul., 6: 29-31, July, 1935) gives several records of porcupines found in the desert areas of southwestern Arizona. Monson (Jour. Mamm., 29: 182, 1948) gives an additional record for a desert area of Arizona, and Jaeger (*ibid.*, 30: 200, 1949) records porcupines from the Mohave Desert of California.

The present record concerns specimens from the lower flood plain of the Rio Sonora, close to the Gulf of California. It represents the first Recent porcupines of this species from Mexico known to me except that Gilmore (*ibid.*, 28: 158, 1947) records many bones from a prehistoric cave in central Coahuila. The record is the extreme southwestern one for the species and is also extreme as to habitat, as the flora and fauna of the area contains some tropical elements.

On November 17, 1941, at Puerto Kino, Sonora, I purchased a live porcupine from a Seri

who had obtained it six days before by setting fire to a woodrat nest in a mesquite tree and so driving it out. Scorched quills on the rump and tail were evidence that the animal had been burned. The animal had been caught about six miles north of Puerto Kino in a mesquite forest growing on the flood plain. It had been kept alive by the Seris as a curiosity. My inquiry for details was hampered by the fact that the Seris did not like to speak Spanish, at least to a strange foreigner, and also because my command of the language was limited. I gathered that the Seris considered porcupines to be exceedingly scarce in the vicinity, but I had the impression that they had known of porcupines there previously. On the other hand, Señor Fernando Camou, who knew the country and the Seris well, had never heard of porcupines there before and doubted that the Seris had either.

I brought the animal alive to Berkeley with the thought that I would keep it alive until it had replaced the burned quills, but on November 25 I prepared it as a skin and skeleton. It is now No. 97792 in the collection of the Museum of Vertebrate Zoology. It was an immature female with the deciduous premolar still in place and weighed 6½ pounds when in poor condition.

I returned to the area a month later and heard further reports of porcupines. At first I thought these all referred to the porcupine I had already obtained, but it became clear that another had been found or the stories hopelessly garbled. However, on January 5, 1942, Señor Luis Felix, of Rancho Palo Alto, in the flood plain of the Rio Sonora, about 15 miles northeast of Puerto Kino, showed me some quills taken from a porcupine killed on a neighboring ranch. Señor Felix had never heard of porcupines in the area before although he obviously knew most of the mammals of the area. He said that this occurrence had excited much local interest and that several people had taken quills as souvenirs. The next day I visited Rancho Santa Ana, about 45 miles west of Hermosillo, and interviewed the proprietor whose name I neglected to record. He took me to the cornfield, which was surrounded by a forest of palo verde, where the porcupine had been found and killed by a boy in November, 1941. The carcass had been hung in a palo fierro, but had been torn down and scattered by vultures and carnivores. I recovered quills, a number of vertebrae, limb bones, ribs, and a skull fragment. These indicated that the animal was about the same size of the one I had obtained at Puerto Kino.

The rancher informed me that he had seen human shaped tracks near the cornfield before the porcupine was killed and had been puzzled by them. The killing of the porcupine settled the identity of the tracks. He also said that tracks had been seen after the porcupine was killed and that they were of two sizes, indicating a mother and young. This indicated that additional porcupines were still in the area. It seems possible that the two specimens obtained were the young since the two were taken in the same month although from places about fifteen miles apart.

The opinion of the ranchers was that the porcupines had strayed into the area from somewhere else rather than that they had been brought by some person because, since local news travels quickly and the area sparsely inhabited, they were sure that they would have heard of any introduction.

In view of the Arizona records cited by Taylor it is probable that the animals came from the northeast by going south through the mountains and foothills and then going west along the Rio Sonora. Although the river is waterless most of the time on the flood plain, trees grow along the stream bed, and in the flood plain there are large stands of palo verde, palo ferre, mesquite and other shrubs of tree size. In view of the wide range of plant materials eaten by porcupines there is little doubt that these could furnish food for them.

I have tentatively identified the specimen as *Erethizon dorsatum couesi*, chiefly on geographic grounds.—Seth B. Benson, *Museum of Vertebrate Zoology, Berkeley, California.* *Received September 14, 1952.*

NUTRIA (*MYOCASTOR COYPUS*) IN CALIFORNIA

Feral nutria, or coypu, have been in Stanislaus County, California, from 1945 to the present (1952) as a result of escapes from a farm located about ten miles northeast of Mo-

desto and about four miles southwest of Oakdale. This extends their range in the West (Larrison, Murrelet, 24 (1): 3–9, 1943). The history of the introduction in California started when about 30 nutria were purchased from Ramsey, New Jersey, in August, 1942, by a fox farm operator located near Oakdale. The animals proved too noisy and were thought to be interfering with the fox breeding, and so the entire lot then consisting of 33 animals was sold to a neighbor on March 5, 1944. This purchaser also received a shipment of eight more nutria from Avery Island, Louisiana, on March 28 of that year. By then the total stock consisted of five males, 13 females and 23 young, five to seven months of age.

It was from the latter location that an unknown number of individuals managed to escape, apparently over a period of several years from 1945, or earlier, to 1948, when feral individuals were first detected. By the end of 1951 more than 100 wild nutria had been trapped, or killed by dogs, in control operations by the Stanislaus County Agricultural Commissioner, U. S. Fish and Wildlife Service, and farmers. Of the adults trapped and sexed, 31 were males; 17 were females. Trapping records indicate that the distribution of the feral population at one time extended at least to the Stanislaus and San Joaquin rivers, in addition to marshes, irrigation canals, and smaller streams bordered by the above rivers and the Tuolumne River. No known population of wild nutria now exists in California; however, it is not likely that all wild individuals resulting from the above escapes have been eradicated.

One reason for believing that the last feral nutria has probably not been destroyed is that the animals are difficult to locate. During 1950, inspectors found evidence of nutria in two swamps, one about two miles west of the escape, the other about one mile to the southeast. The Fish and Wildlife Service county predatory-animal trapper, whose assistance was requested, removed 15 animals from one swamp. When no more were caught or sign seen he moved to the next swamp. No individuals were trapped in the second swamp, and no further indications of their presence in either area were found even though both places were surveyed several months longer. In 1951, however, the trapper again set traps in the two swamps and caught a total of 30 animals.

The first indication that nutria had escaped near Oakdale was in 1948, when Milo M. Schrock, Agricultural Commissioner of Stanislaus County, received a complaint that muskrats had caused a break in the bank of an irrigation canal. Investigation revealed that the break had been caused by nutria. It was then learned that the game warden of the Department of Fish and Game had recently been asked by a farmer for permission to kill beaver that were damaging ditch banks. Permission was granted since the warden knew there were no beaver in the area. The farmer pumped the water out of the tule-lined ditch, which was close to the nutria-caused break, and reported that he and his dog killed 35 nutria in the drained area.

Nutria are not desired as a fur bearer in California, because their potential hazard to many of the highly developed and diversified agricultural crops outweighs the small yield of fur that would be produced (Atwood, Jour. Wildlife Mgt., 14: 249–265, 1950). Much of the cultivated land in the State is irrigated by means of canals, and the burrowing habit of coypu might be costly in the destruction of ditch banks as is the case with muskrats, which are established in the Sacramento Valley and are considered more of an agricultural pest than a fur resource by the Department of Fish and Game. Some of the drained and cultivated delta region protected by levees, where the Sacramento and San Joaquin rivers merge, is as much as 15 and 20 feet below high tide and flood level. Also much of the State's cultivated land is protected from flood waters by dirt banks. It is obvious, then, why Milo M. Schrock, who provided much of the information for this report, and others of us are justly concerned about the establishment of nutria in California.—Walter E. Howard, *Zoology Department, University of California, Davis.* *Received October 28, 1962.*

A TRIGGER MECHANISM FOR SMALL-MAMMAL LIVE TRAPS

Development of the mechanism described herein (Fig. 1) is the result of a suggestion by Tracy I. Storer to construct a wire trigger something like the one used by Chitty and Kemp-

son (Ecology, 30: 536–542, 1949), which utilizes the see-saw type of treadle originated by Seth B. Benson and William H. Burt at the University of Michigan. The objective was to have a mechanism that is simple to construct, easy to repair, and relatively free of the floor of the trap so that bait and other debris would not interfere with the working parts. (These requirements have also been satisfied by a trap designed by Fitch, Jour. Mamm., 31: 364–365, 1950.)

The proportions between the lengths of the different arms of the wire trigger are easily determined by trial and error for any size trap or wire used. Fairly heavy wire is recommended; No. 11 galvanized wire (W & M Standard Wire Gauge) proved more satisfactory than No. 16. When the two ends of the wire are held between the fingers, the mechanism should rock forward if properly balanced. After a trap has been assembled it is still easy to remove the trigger with one's fingers and bend the wires to alter its sensitivity. The ends of the wire may project through holes on the sides of the trap or, to avoid having the ragged

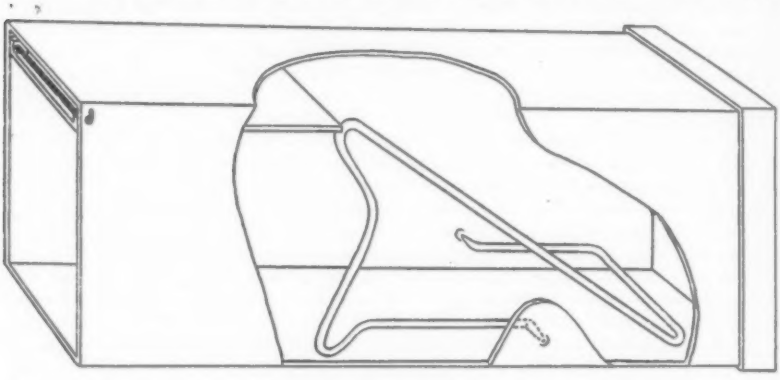

FIG. 1.—A cut-away view of the wire trigger mechanism. Small indentations in the trap walls hold the blunt but pointed ends of the wire in place.

ends sticking outside the trap, a better method is to make small indentations in the walls to hold the blunt-pointed ends of the trigger in place.

There is no limitation as to the size of traps incorporating this type of trigger. The traps are easily set by holding them horizontal and pushing the door open. When the door is opened it rocks the counter-balanced trigger backwards, but the device quickly settles forward again and holds the door open. The trap is set off when an animal gets near the back and touches the wire trigger. The mechanism has been used successfully for several years in traps constructed both of sheet metal and of hardware cloth.

Acknowledgements are due Robert Holdenried, Daniel H. Brandt, Jay C. Quast, and David H. Wiltsie for their assistance in testing the trigger design in field trapping and for their favorable reports on its success. Also, appreciation is expressed to Young's Animal Trap Co., Sunnyvale, California, for their cooperation in manufacturing live traps made of hardware cloth that contain the above-described trigger.—WALTER E. HOWARD, *Department of Zoology, University of California, Davis.* *Received October 23, 1952.*

COMPARISON OF CATCH OF TWO SIZES OF SMALL-MAMMAL LIVE TRAPS

During the live-trapping of small rodents at the San Joaquin Experimental Range, O'Neals, California, using Sherman-type traps of two sizes, 3 x 3 x 10 and 2 x 2.5 x 6.5 inches, it soon became apparent to the junior author that the larger models were more successful.

Dr. Henry S. Fitch, who was formerly at the Range and used both sizes of traps, says he also had found that the larger traps were more successful in catching small rodents. To verify these views by making a comparison between the catch of the two kinds of traps, the senior author kept a record of the size of the trap animals were caught in during part of another study (Habitat preferences of rodents on grazed and ungrazed foothill pastures in California, Univ. Calif., M.A. Thesis, 1950).

The test was designed to be as random as possible with regard to the distribution of the two sizes of traps. All traps were cleaned and the triggers checked for sensitivity before the experiment was started. The trapping was done between January 17 and March 7, 1950, on four separate plots, each four acres in extent, with the traps placed at the intersections of a 30-foot grid. Each plot was trapped with 128 live traps, 64 large and 64 small ones. During the first four nights of trapping on each plot, a center square of approximately two acres was covered; the traps were then moved from the center square to a peripheral region of two acres and placed at 30-foot intervals as before, where they were set three, or sometimes four, nights. Captured rodents were marked and then released. Cereal baits were used, a small amount of "forebait" being sprinkled just outside and in the front part of the trap to help overcome the initial reluctance of some individuals to enter an unfamiliar trap. During cold weather large amounts of bait rather than nesting material were put in the traps to prevent the captured rodents from dying of "cold weather starvation" (Jour. Mamm., 32: 300-312, 1951).

Eighty-three individuals of three species of *Peromyscus* and one species of *Dipodomys* were live-trapped a total of 291 times, and the results clearly indicate that more animals were captured in the larger models. Of the 243 captures of *Peromyscus*, 222 (91 per cent) were in the large traps. By species, 90 per cent of 49 captures of *P. maniculatus*, 93 per cent of 58 *P. boylei*, 91 per cent of 136 *P. truei*, and 58 per cent of *Dipodomys heermanni* were captured in the larger traps. It is of interest, however, that 42 per cent of the kangaroo rats, which are larger than white-footed mice, were caught in the small traps, as compared to nine per cent of the captures of *Peromyscus* in small traps. When the home ranges were plotted, it was evident that a number of *Peromyscus* apparently passed a small trap to enter a large one.—Jay C. Quast and Walter E. Howard, *Department of Zoology, University of California, Davis.* *Received October 28, 1952.*

ACCIDENTAL DEATH OF A MULE DEER IN IDAHO

On March 15, 1952, while studying the winter range conditions of elk and deer on the Lochsa and Selway river drainages, the writer found a mule deer (*Odocoileus hemionus hemionus*) which had hanged itself in a yew tree (*Taxus brevifolia*).

The yew tree was growing below an abrupt bank at the edge of Deadman Creek (300 to 350 yards from the Lochsa River). A cover of crusted snow approximately three feet deep recorded the series of events leading to the fatal accident. This deer was able to travel on top of the crusted snow and, from the abrupt bank, browse parts of the yew otherwise beyond reach. Undoubtedly overzealous in its attempt to get the choice twigs of yew, the deer walked to the very edge of the snow-capped bank, and while it was stretching to reach the twigs the snow gave way beneath the animal. It plunged forward and was hanged by the neck in the fork of the yew tree.

Bobcats had visited the accidental kill and feasted on the hind quarters. The stomach contents revealed that this deer had been feeding heavily upon yew browse. This big game range has been heavily used by elk which have taken much of the browse within reach of deer, thereby forcing deer into closer utilization of browse.—Edwin B. Caswell, *Brownlee Ranger Station, Cambridge, Idaho.* *Received October 4, 1952.*

NEW LOCALITY RECORDS FOR SOME MAMMALS OF EASTERN TEXAS

One of the least known areas in Texas from the standpoint of mammalian ecology is the east Texas timbered region. Bailey (North American Fauna No. 25, 1905) did the most extensive collecting that has been done in this region. Various other independent collectors

have done some work here, but since Bailey's publication there has been a paucity of published material on the mammals of eastern Texas. Thirty species of mammals were recorded from this region. Of these, six deserve special mention because of range extensions or additional ecological data.

One Mexican free-tailed bat (*Tadarida mexicana*) was collected Nov. 2, 1950 on the campus of Stephen F. Austin State College, Nacogdoches. So far as can be determined this is the most easterly record for this species.

Blarina brevicauda carolinensis has been previously known in Texas only from Aransas, Hardin, and Shelby counties. We have collected this shrew in the following counties: Cherokee, Harrison, Nacogdoches, Rusk, Sabine, and Shelby. In Nacogdoches County it was taken in considerable numbers in a grassy pasture one mile east of Nacogdoches. In Harrison and Sabine counties it was collected in pine-oak uplands. In Cherokee and Shelby counties it was found living on densely wooded floodplains. These records extend the known range of *Blarina brevicauda* in Texas both north and west of its previously known distribution. The fact that it was found in a variety of habitats indicates that it is probably more abundant in eastern Texas than was previously believed.

Reithrodontomys humilis merriami is apparently one of the rarest mammals in Texas. It was previously known in Texas only from the coastal prairie region. Specimens were collected in the fall of 1950, one mile east, and 15 miles southwest of Nacogdoches, Nacogdoches County. All of the specimens were captured in grassy pastures that contained a scattered growth of blackberry vines. These records extend the known range of this species into the timbered region of eastern Texas and some 180 miles north of its previous known occurrence.

Peromyscus gossypinus megacephalus is the most common small mammal of eastern Texas. It occurs primarily in low forested floodplains but during peaks of population highs it frequently occurs in the uplands. We collected this species in the floodplain of the Trinity River in northwestern Henderson County and 20 miles northwest of Palestine in Anderson County. Prior to these records *P. gossypinus* was not known definitely to extend this far west.

The golden mouse (*Peromyscus nuttalli*) was found to be widespread in its distribution over eastern Texas but not particularly abundant in any locality. Two specimens were collected in Anderson County, 20 miles northwest of Palestine. This record is approximately 120 miles west of the previous known range of the golden mouse in Texas.

Pitymys pinetorum nemoralis has been previously recorded in Texas in only three localities (Bailey, *op. cit.* and Bryant, Jour. Mamm. 22: 2, 1941). We found an additional population of *Pitymys* in a grassy marsh one mile east of Nacogdoches. Pine voles were abundant here in the fall and winter of 1950–51. The area was burned in the summer of 1951 and since that time no voles have been collected.—W. H. McCarley and W. N. Bradshaw, *Department of Zoology, University of Texas, Austin 12.* *Received November 3, 1952.*

CHECKLIST OF PALAEARCTIC AND INDIAN MAMMALS—AMENDMENTS

We recently (Jour. Mamm., 34: 151, 1953) gave notice of our intention to publish some amendments to the above work, and asked colleagues to send us a note of errors which they had themselves noticed. We do not know whether to be gratified or dismayed, but we have received no communication. We are, however, grateful to Mr. G. H. Swynnerton, who had previously sent us corrections, some of which are incorporated below. This list is not exhaustive, but gives those amendments which we deem important.

Page

4. Brünnich, Zool. Fundamenta dates from 1771.
12. Koh Lak is a small island off the east coast in about 11.45 N.
15. The reference of *Elephantulus rozeti* should read: Mém. Soc. Hist. Nat. Strasbourg, 1, 2: art. 4, 18. Near Oran, Algeria.
17. The type species of *Hylomys* is *Hylomys suillus* Temminck.
23. The reference of *Erinaceus algirus* should read: Mém. Soc. Hist. Nat. Strasbourg, 3, 2: art. 1, 4.

Page

55. *Sorex cylindricauda* should date from 1872.
65. The author of *Paradoxodon* is Wagner.
67. Add *Suncus murinus temminckii* Fitzinger, 1868. *Pachyura temminckii* Fitzinger, 1868, S. B. Akad. Wiss. Wien., 57: 141. Kiushiu Island, Japan.
85. *Crocidura olivieri* Lesson 1827 was published in May; this is a race of *Crocidura flavescens* I. Geoffroy, January, 1827 (*Sorex flavescens* I. Geoffroy, Dict. Class. 11: 324, King Williams Town, Cape Province (Roberts)). Distribution: from Cape Province through most of Africa south of the Sahara, northwards to Egypt.
93. The reference of *Rousettus seminudus* is: *Pteropus seminudus* Kelaart, 1850, J. Ceylon Branch Asiatic Soc., 2: 216. Mt. Lavinia, Ceylon.
104. The reference of *Saccolaimus* is: *Saccolaimus* Temminck, 1838, Tijdschr. Natuur. Gesch. 5: 6. *Taphozous saccolaimus* Temminck.
105. To distribution of *Taphozous nudiventris* add Tanganyika.
107. *Nycteris hispida* dates from 1774. *Nycteris tragata*, which has the upper incisors bifid, should be regarded as a species distinct from *N. javanica*, which has the upper incisors trifid. *Nycteris thebaica* ranges to the Cape of Good Hope.
108. The page number of *Megaderma* is 190 and the type locality of *Megaderma spasma* is Ternate.
112–113. *Rhinolophus acrotis* is not a valid species and should be merged with *clivosus* (according to Sanborn), which ranges to the Cape Province.
124. *Hipposideros speoris* dates from 1797 vel 1798.
131. Sanborn, 1952, Nat. Hist. Misc. no. 97: 2, says that *Aselliscus wheeleri* is a synonym of *Aselliscus stoliczkanus:* (*Asellia stoliczkana* Dobson, 1871, Proc. Asiat. Soc. Bengal, 106, Penang).
133. To distribution of *Tadarida teniotis* add Asia Minor (B.M.)
134. To distribution of *Tadarida aegyptiaca* add Ceylon (B.M.).
136. Add: Subgenus *Mops* Lesson, 1842. *Tadarida midas* Sundevall, 1843. (*Dysopes midas* Sundevall, K. Svenska Vetensk. Akad. Handl. 1842: 207. Bahr-el-Abiad, Sudan). Specimens recently received in British Museum from Arabia. Distribution also includes Eritrea, Senegal, Nigeria, Nyasaland and Madagascar.
136. The date of publication of *Dysopes pumilus* is '1830 vel 1831'.
153. *Pareptesicus* and *Rhyneptesicus* Bianchi date from 1917.
156. To distribution of *Eptesicus isabellinus* add Algeria.
178. *Scotophilus nigrita* dates from 1774. *Scotophilus kuhli* dates from 1821.
183. To distribution of *Miniopterus schreibersi blepotis* add Bangkok, Siam (Chasen).
184. To distribution of *Miniopterus australis* add Siam (Tate).
187. Delete *Nyctophilax*.
241. *Helarctos malayanus* dates from 1821.
243. Delete reference to *Zorilla*.
247. *Martes melampus* dates from 1841.
249. Add; 1943. *Martes zibellina averini* Bashanov, Izvest. Kazakstan Branch Acad. Sci. U.S.S.R., 1942, Alma-Ata, 1943, p. 53. Katon-Karagai region, southern Altai. (N.V.).
255. The type locality of *Putorius kanei* Baird, 1857, Mammals of North America, 172, was fixed by E. Raymond Hall (1944) as Arikam Island, Bering Sea, Siberia. This name should supersede *M. e. orientalis* Ognev.
267. Add; 1948, *Vormela peregusna pallidior* Stroganov, Travaux Zool. Inst. Acad. Sci. U.S.S.R., 7: 129. Kopal district, Semirechyia. (N.V.).
274. The reference to *Meles meles danicus* is Degerböl, 1933, Danmarks Pattedyr i Fortiden, 574, 634. Sjaelland, Denmark.
285. *Prionodon pardicolor* dates from 1841.
288. *Paradoxurus zeylonensis* dates from 1778. *P. hermaphroditus milleri* is preoccupied and has been renamed *conisbeei* Ellerman & Morrison-Scott, 1952, J. Mamm. 33: 399.
293. *Calogale*, *Calictis*, *Taeniogale* and *Onychogale* date from 1865.
316. The reference to *Felis panthera* is Schreber, Säugth. pl. 99 (1775), 3: 586 (1778).

Page

320. *Panthera uncia* dates from 1775. The reference is: Säugth. pl. 100; text, 3: 586 (1778).
Achinonyx jubatus dates from 1775. The reference is: Säugth. pl. 105, text, 3: 393 (1777).
Delete *Guepardus* and *Cynofelis*. The former is based on *Felis guttatus* Hermann, which is unidentifiable but certainly not a cheetah, and the latter is a substitute for the former.

327 and 330. *Pagophila* Kaup does not preoccupy *Pagophilus* Gray, which is therefore valid as a subgenus rather than *Pagophoca*.

329. The reference to *Phoca hispida* is: 1775. Säugth. pl. 86; text, 3: 585 (1778).

335. To distribution of *Procavia capensis* add southern Egypt (B.M.).

340. *Ceratorhinus* dates from 1868 (P.Z.S. 1867: 1021).

357, 358. *Elaphodus* and *Elaphodus cephalophus* date from 1872.

393. In the reference of *leptoceros* the number '72' refers to the 'livraison', and is not a page number.

419. The date of Lyon's paper is.1904.

444. *Pentalagus* dates from 1904.

445. To synonymy of *Ochotona* add:
Abra Gray, 1863, Cat. Mamm. Hodgson Coll. 2nd ed., 11. *Lagomys curzoniae* Hodgson. Not of Lamarck, 1818.
Abrana Strand, 1928, Arch. Naturgesch. 92, 8: 59. New name for *Abra* Gray.

450. *Ochotona thibetana* dates from 1872.

469. According to G. H. H. Tate *in litt.* the name *Sciurus sagitta* was based on a *Petinomys*. Therefore the name for the species listed as *Hylopetes sagitta* will be Hylopetes lepidus (*Pteromys lepidus* Horsfield, 1822, Zool. Res. Java, no. 5, pl. & text, unnumbered. Java).

477. The author of *Sciurus anomalus* is Schreber.

495. To distribution of *Funambulus pennanti* add southeastern Persia (B.M.).

552. *Rhizomys sumatrensis* dates from 1821.
Cannomys badius dates from 1841.

555. To distribution of *Spalax leucodon* add Iraq (R. T. Hatt).

559. *Chiropodomys gliroides* dates from 1856.

563. To synonymy of *Apodemus* add: 1939. *Karstomys* Martino, Zap. Russk. Nauch. Inst. Byelgrad, 14: 88. *nom. nov.* for *Petromys* Martino *nec* Smith.

568. To synonymy of *Apodemus sylvaticus sylvaticus* add: *Sylvaemus sylvaticus sylvaticus hessei* Martino, Crni Kamen, Sar planina mountains near Kacanik and *S. s. s. dichruroides*, from Kocane, both Yugoslavia, Martino, Recueil de Trav. offert à J. Georgevitch, Belgrade, 1933, 301.

577. Subsequent researches on African subgenera of *Rattus* lead us to the belief that *Millardia* is not more than a subgenus of *Rattus*.

615. The type species of *Acomys* is *Mus cahirinus* Desmarest.

617. *Bandicota bengalensis* dates from 1835.

619. *Nesokia indica* dates from 1830.

620. The reference to *Calomyscus* is 1905, Abstr. P. Z. S., no. 24: 23.

621. The reference to *Calomyscus bailwardi* is the same as for *Calomyscus*, plus P. Z. S. 1905, 2: 525 (1906).

634. *Gerbillus gerbillus* dates from 1800.

668. *Eothenomys melanogaster* dates from 1872.—J. R. Ellerman and T. C. S. Morrison-Scott, *British Museum (Natural History), London, S.W. 7. Received May 1, 1953.*

CORRECTION TO "THE MAMMALS OF SOUTH AFRICA"

In his review of the late Dr. Austin Roberts' book "The Mammals of South Africa", Dr. Henry W. Setzer (Jour. Mamm., 34: 141, 1953) points out that "the legends for, and the species guide to, coloured plates V and VI are hopelessly confused". On examination it has proved that the references in the text and in the index agree with each other and with those

of the legends to the two plates concerned, but that none of these agree with the forms as depicted in the plates. I attempted to clear up this confusion by comparison of specimens representing those forms mentioned in the text with the ones depicted in plates V and VI. Unfortunately Dr. Roberts did not note the catalogue numbers of the specimens reproduced, so that exact comparison is impossible. However, I selected what I considered were representative specimens of each of the forms concerned and based my comparison on these.

The first fact that appeared was that the two plates, *but not their legends*, were reversed, so that in fact the legend for Plate V refers to Plate VI and *vice versa*. Furthermore, the forms depicted on the plates themselves do not agree with those names with corresponding numbers in the legends, but are again confused. As far as it was possible to determine, the figures on the plates should be numbered as follows:

PLATE V	PLATE VI
Fig. 1.—Plate VI, Fig. 3.	Fig. 1.—Plate V, Fig. 8.
" 2.— " " " 1.	" 2.— " " " 2.
" 3.— " " " 8.	" 3.— " " " 1.
" 4.— " " " 2.	" 4.— " " " 7.
" 5.— " " " 5.	" 5.— " " " 5.
" 6.— " " " 7.	" 6.— " " " 4.
" 7.— " " " 4.	" 7.— " " " 6.
" 8.— " " " 9.	" 8.— " " " 3.
" 9.— " " " 6.	" 9.— " " " 9.

J. MEESTER, *Division of Mammalogy, Transvaal Museum, Pretoria, S. Africa.* *Received May 20, 1953.*

REVIEWS

Sumner, Lowell and Joseph S. Dixon. BIRDS AND MAMMALS OF THE SIERRA NEVADA. Berkeley and Los Angeles. University of California Press, xvii + 484 pp., 8 colored plates, 46 figs., 2 maps. Price, $7.50.

Sumner and Dixon's *Birds and Mammals of the Sierra Nevada* is a popular presentation of the data obtained from a number of surveys made by the Museum of Vertebrate Zoology and of their own original studies in Kings Canyon and Sequoia National Parks. It will serve as a replacement for *Animal Life in the Yosemite* by Grinnell and Storer, the standard reference which is now generally unavailable; and, although the data and records pertain specifically to Kings Canyon and Sequoia National Parks, the descriptions and accounts of habits include the great majority of species that campers and hikers will encounter anywhere in the Sierra Nevada.

The introductory sections contain an excellent explanation of the philosophy and policies governing the administration of national parks. There is, after the style of the Yosemite report, a discussion of the life zone classification, demonstrating the relationships of elevation, weather and vertebrate biology to the layman. The authors explain how exceptions to the life zone classification may occur, how the differences in exposure, moisture, and air currents can alter the superficially discrete floral and faunal divisions. The life zone, map (in black and white) for the two parks is rather oddly placed at the back of the book quite apart from the descriptions of the life zones. A number of well selected photographs illustrate the characteristic environments of the life zones and some of the birds and mammals. Several photographs of overgrazed and non-grazed meadows will help the reader appreciate the authors' continual plea for careful land use and protection for park areas. The radically unbalanced placement of two of the photographs (Figs. 41 and 44) may represent an editor's effort at distinction, but results in a distraction in the otherwise attractive

arrangement. The color plates by Allan Brooks add considerably to the attractiveness of this book.

The bulk of the text is devoted to descriptions and discussions of the birds and mammals arranged by species, each specific account being divided into a description, a summary of distinctive habits and a list of park records. The comments for the species have been very carefully prepared and make this volume applicable for most of the birds and mammals throughout the Sierra Nevada. The descriptions contain information on weight, voice, form, and color, and frequently compare allied species; far from being telegraphic listings of characters, they form brief, readable introductions to the accounts of habits. The authors' field experiences contribute to the excellence of the accounts of habits and they have included numerous first hand descriptions which were previously unpublished; the comments on the coyote and mountain lion are especially fine. There is, perhaps, a too frequent use of unaltered field notes; for example, "A male [sooty grouse] was observed on April 20, 1933, sitting lengthwise on a limb, 60 feet up in a ponderosa pine, his tail toward the trunk. He was hooting at intervals of thirty to one hundred seconds." Occasional mention of the authors' experiences provide a fresh atmosphere in a popular book; but when poorly selected and used too frequently, they make the reading difficult and dull.

The use of lower case letters for names of species is a much desired departure from the frequent practice of capitalizing these names, especially for birds. The common names apply to species with no distinction being made for subspecies, thus eliminating a cause of confusion found in many books. The spelling pinyon, for piñon, is unnecessary and confusing; piñon is a well-known word and pinyon will be unknown to most readers and is not to be found in most large dictionaries.

This volume is an excellent replacement for the rather rare earlier books on the vertebrate faunas of Lassen and Yosemite parks; and, while less bulky, it contains considerably more information on the birds and mammals. It will doubtless become a standard guide for those who wish to learn about and observe the Sierra Nevadan birds and mammals.—E. W. Jameson, Jr., *Department of Zoology, University of California, Davis.*

Mayr, Ernst; E. Gorton Linsley; and Robert L. Usinger. Methods and Principles of Systematic Zoology. New York. McGraw-Hill Book Company, ix + 328 pp.; illus. 1953. Price, $6.00.

This work should prove to be of great value to all mammalogists, whether taxonomists or not. The principles set forth in such a lucid and complete manner are those with which all students of mammals should be familiar. The young student of taxonomy will find the details of procedure described with clarity; the older student will find this work a handy reference.

The background for taxonomy is no less important than for any other discipline of science, and the authors present, in part 1, chapters on the history and functions of taxonomy, a discussion of the species and intraspecific categories, and a discussion of classification and the higher categories.

Part 2 of the book presents the details of taxonomic procedure with an admirable degree of completeness. These range all the way from the selection of a taxonomic problem to the presentation of the final data in print. A thorough discussion of identification and taxonomic discrimination includes a detailed survey of the many types of variation found in animals. The confusion that has resulted from the lack of recognition of individual variation in animal populations is emphasized. For mammals this might be even more strongly emphasized, as illustrated by recent studies of the range of individual variation in large populations.

The relative values of various types of taxonomic characters are presented, including morphological, physiological, ecological, ethological, and geographical characters. On page 109, the authors mention briefly the use of "genitalic structures" as taxonomic characters, and point out their value for discrimination at the species level. Presumably they refer here to external genitalia only, and, although not mentioned, the recent rather ex-

tensive use of the baculum in mammals is a good example. It might have been useful, at this point, to mention the relatively conservative nature of the internal genital organs and their value in phylogeny at higher taxonomic levels—in mammals at least.

The chapter on quantitative methods of analysis is an excellent introduction to the statistics of biology, and most of the usual methods of analysis, measures of variability, and methods of presenting data are covered here in compact fashion, with ample references to more detailed sources of information.

The preparation of adequate keys, descriptions of taxonomic entities, and classifications are thoroughly discussed. This is followed by a discussion of the preparation of taxonomic papers, a discussion that might well apply to the preparation of scientific papers in general, and one that editors might wish their authors would study carefully!

A section on zoological nomenclature answers many important questions for the taxonomist and others, ranging from the history of nomenclature through the principle of priority, the type method, the rules for the formation of Latin names in all categories, to the ethics of taxonomy. A useful bibliography, glossary, and index complete the book.—W. Robert Eadie.

Lindsdale, Jean M., and P. Quentin Tomich. A Herd of Mule Deer: A Record of Observations Made on the Hastings Natural History Reservation. University of California Press. Berkeley and Los Angeles. xiii + 567 pp., 174 text figs., 4 pls., tables. 1953. Price, $8.50.

This work contains a wealth of observations and data on the mule deer, but, like previous studies emanating from the Hastings Natural History Reservation, much of the material is presented in an undigested form, with repeated observations of the same phenomenon. That this is deliberate on the part of the authors is, by now, very clear, and is explained in the preface of this book by the statement that "For the purpose of demonstrating the deer's many responses to a wide range of environmental situations in one locality, a series of examples provides a better understanding than would the combined treatments of them or an attempt to select typical responses." Despite this viewpoint, most readers of the book will have expected the writers to have synthesized the data more than they have, since they are in the best position to do it.

The passion for reporting all the details of each field observation sometimes reaches the point of ludicrousness. For example, under "Licking" in the chapter on "Mannerisms" we find that "A grazing doe stopped and swung her head around to the right, giving seven firm strokes along 4 inches of the sacrum just anterior to the base of the tail." Are we to assume that it would have been significant if she had swung her head to the *left* and given only *five* firm strokes along *six* inches of the sacrum? Again, "On March 26 a large buck with growing antlers 3½ inches long licked at his perineal region." Is it possible that a buck with five-inch antlers might not do so?

In the chapter on structure there is an exhaustive treatment of the gross morphology, succession, growth, and loss of antlers that leaves few questions unanswered. (One wonders, however, at the significance of a cast antler being found on a "3 per cent slope" at the base of a coffeeberry bush.) Tooth succession, wear, and abnormalities are also fully reported in this section.

Much interesting information is presented in the chapter on communication, including sounds, movements, and scent. A detailed description of skin glands and observations on their possible uses are given. The assumption on page 107, that the material in the "preocular gland" is dried secretion from the lacrimal fluid seems to be poorly supported by the observations made. It would seem more logical to actually investigate the gland than to speculate and then draw unsupported conclusions. Hearing, vision, and smell are discussed, with field observations. A chapter on mannerisms contains many interesting notes on the habits of mule deer—Nimrods and archers take note!

There is a long chapter on animal associates that contains, among other observations, some fascinating notes on the relations between jays, magpies, and mule deer, as well as

interesting notes on the relations between wildcats and the deer. Habitat is discussed at length in relation to the mule deer, and there are detailed chapters on activity and food. Reproduction is described from the observational standpoint from detailed field notes. The data on population are limited by the small size of the herd, observed on a limited area.

There is much of value in this work, but one cannot help but observe that it could have been presented in much less space in a publication of more reasonable cost. The book is handsomely prepared, and generously illustrated with line drawings, graphs, and halftones.—W. Robert Eadie.

RECENT LITERATURE

(Conducted by David H. Johnson, Claude W. Hibbard, Richard H. Manville, and Henry W. Setzer)

[Reprints of this section may be purchased from the Corresponding Secretary]

Aellen, Villy. Contribution a l'étude des chiroptères du Cameroun. Mem. Soc. Neuchateloise Sci. Nat., vol. 8, pp. 1–121, illus. 1952. (New: *Nycteris benuensis*)

Albisson, P., and J. Dorst. Notes sur l'élevage de chauves-souris en captivité. Mammalia, Paris, vol. 15, no. 4, pp. 170–174. December, 1951.

Anciaux de Faveaux, Dom F. Observations sur les chiroptères de la grotte de la Baume-Granat à Roquefort-les-Pins (Alpes-Maritimes). Mammalia, Paris, vol. 16, no. 3, pp. 148–156, illus. September, 1952.

Anonymous. Too lazy to leave. Life, Chicago, vol. 33, no. 17, p. 158, illus. October 27, 1952. (Three-toed sloth)

Anonymous. Rosie—the tale of a rabbit. Michigan Conservation, Lansing, vol. 22, no. 1, pp. 20–22. January, 1953.

Anonymous. Whitetail census. Michigan Conservation, Lansing, vol. 22, no. 3, pp. 16–18, illus. May, 1953.

Anthony, J. Disposition exceptionnelle du *sulcus arcuatus* sur le lobe frontal d'un atèle (singes platyrhiniens). Mammalia, Paris, vol. 16, no. 3, pp. 157–159, illus. September, 1952.

Arambourg, C. Note preliminaire sur quelques elephants fossiles de Berberie. Bull. Mus. Nat. Hist. Nat., Paris, ser. 2, vol. 24, no. 4, pp. 407–418, illus. 1952. (New: *Elephas africanavus; Elephas pomeli*)

Aretas, Raymond. L'eléphant de mer (Mirounga leonina (L.)). Étude biologique de l'espèce dans les possessions françaises australes (Archipel des Kerguelen). Mammalia, Paris, vol. 15, no. 4, pp. 105–117. December, 1951.

Baudenon, Paul. Notes sur les bovidés du Togo. Mammalia, Paris, vol. 16, no. 2, pp. 48–61; no. 3, pp. 109–121. June, September, 1952.

Bemmel, A. C. V. van. One of the rarest deer of the world. Beaufortia, Zool. Mus. Amsterdam, no. 27, pp. 1–5, illus. February 18, 1953. (*Hyelaphus kuhlii*)

Billingham, R. E., and P. B. Medawas. A study of the branched cells of the mammalian epidermis with special reference to the fate of their division products. Philos. Trans. Royal Soc. London, ser. B, vol. 237, no. 644, pp. 151–171. March 10, 1953.

Bird, J. Brian. The naming of the walrus. Arctic, Jour. Arctic Inst. North America, Ottawa, vol. 6, no. 1, pp. 62–63. March, 1952.

Biswell, H. H., R. D. Taber, D. W. Hedrick, and A. M. Schultz. Management of chamise brushlands for game in the north coast region of California. California Fish & Game, San Francisco, vol. 38, no. 4, pp. 453–484, illus. October, 1952.

Blair, W. Frank. Experimental evidence of species discrimination in the sympatric species Peromyscus truei and P. nasutus. Amer. Nat., vol. 87, no. 833, pp. 103–105. March–April, 1953.

BOARDMAN, W. The hair tracts of marsupials. Part V. A contribution on causation. Part VI. Evolution and genetics of tract pattern. Part VII. A system of nomenclature. Proc. Linnean Soc. New South Wales, vol. 75, pts. 5–6, pp. 254–278, illus. December 21, 1950.

BOONE AND CROCKETT CLUB. Records of North American Big Game. Charles Scribner's Sons, New York, pp. xiii + 174, illus. 1952. (Compiled and edited by the Committee on Records of North American Big Game, Samuel B. Webb, Chairman. Signed articles include: The official scoring system for North American big game trophies, by Samuel B. Webb; Objectives and conditions of the North American big game competition, by Milford Baker; What happened to former world records under the official scoring system, by Grancel Fitz; Ranges of the Columbian blacktail, by T. Donald Carter; The care of trophies in the field, by James L. Clark; The care of mounted trophies, by James L. Clark.)

BOROWSKI, STANISLAW. Saisonale Veränderungen der Behaarung der Soricidae. Ann. Univ. Mariae Curie-Sklodowska, vol. 7, no. 2, pp. 65–117. July 25, 1952.

BOYDEN, ALAN. Fifty years of systematic serology. Systematic Zool., Washington, vol. 2, no. 1, pp. 19–30, illus. March, 1953. (*Dasypus, Manis, Orycteropus*)

BRAZDA, ARTHUR R. Elk migration patterns, and some of the factors affecting movements in the Gallatin River drainage, Montana. Jour. Wildlife Management, Ithaca, vol. 17, no. 1, pp. 9–23, illus. January, 1953.

BURNET, FRANK MACFARLANE. Myxomatosis as a method of biological control against the Australian rabbit. Amer. Jour. Public Health, Albany, vol. 42, no. 12, pp. 1522–1526. December, 1952.

BURTON, MAURICE. Tree-climbing goats. Illus. London News, vol. 222, no. 5936, p. 118, illus. January 24, 1953.

CLOTHIER, RONALD. Taxonomy of the *Sorex vagrans-obscurus* group in western Montana. Proc. Montana Acad. Sci., vol. 10, pp. 11–12. 1951.

CONAWAY, C. H., AND J. C. HOWELL. Observations on the mammals of Johnson and Carter counties, Tennessee, and Avery County, North Carolina. Jour. Tennessee Acad. Sci., vol. 28, no. 1, pp. 53–61. January, 1953.

COUTURIER, MARCEL A. J. Note sur deux trophées exceptionnels (2e et 3e records français) d'isard (*Rupicapra rupicapra pyrenaica*). Mammalia, Paris, vol. 16, no. 4, pp. 253–255. December, 1952.

CREUTZ, GERHARD. Die Waldmaus, *Apodemus s. sylvaticus* (Linné, 1758), als Bewohnerin von Nistkästen. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 21–22. January 10, 1953.

CREUTZ, GERHARD. Schwimmendes Kaninchen, *Oryctolagus c. cuniculus* (Linné, 1758). Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, p. 22. January 10, 1953.

CREUTZ, GERHARD. Zur Ernährungsweise des Eichhörnchens, *Sciurus vulgaris fuscoater* Altum, 1876. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, p. 31. January 10, 1953.

DALIMIER, PAUL. Remarque au sujet du polymorphisme du molot en Belgique. Bull. Inst. Royal Sci. Nat. Belgique, Brussels, vol. 28, no. 63, pp. 11. December, 1952.

DALQUEST, WALTER W. Two new mammals from central Mexico. Proc. Biol. Soc. Washington, vol. 64, pp. 105–108. August 24, 1951. (New: *Pipistrellus hesperus potosinus, Citellus spilosoma cabrerai*)

DAVIES, J. The anatomy of a twenty-two millimetre embryo of the African rhinoceros (*Rhinoceros bicornis*). Proc. Zool. Soc. London, vol. 122, pt. 3, pp. 593–613, illus., pls. 6. November, 1952.

DAVIS, BETTY SCHUCK. Studies on the trypanosomes of some California mammals. Univ. California Publ. Zool., vol. 57, no. 3, pp. 145–249, illus. October 17, 1952. (Includes discussion of life history of *Zapus princeps alleni*.)

DECERISY, J. L. Remarques à propos du cercle de Willis des Primates. Mammalia, Paris, vol. 16, no. 4, pp. 213–215. December, 1952.

DEKEYSER, P. L. Les pangolins. Notes Africaines, Dakar, no. 57, pp. 27–30. January, 1953.

DICE, LEE R., AND ELIZABETH BARTO. Ability of mice of the genus *Peromyscus* to hear ultrasonic sounds. Science, vol. 116, no. 3005, pp. 110–111. August 1, 1952.

DICE, LEE R. Quantitative and experimental methods in systematic zoology. Systematic Zoology, Washington, vol. 1, no. 3, pp. 97–104. September, 1952.

DIDIER, ROBERT. Description de l'os pénien de Chrysocyon jubatus (Desmarest) et de Felis (Uncia) uncia Schreber. Bull. Inst. Roy. Sci. Nat. Belgique, Brussels, vol. 28, no. 56, pp. 1–4. November, 1952.

DIDIER, ROBERT. Note sur les os péniens de pinnipèdes rapportés par M. Patrice Paulian de la Mission Australe Française aux Îles Kerguelen. Mammalia, Paris, vol. 16, no. 4, pp. 228–231, illus. December, 1952.

DORST, JEAN. Note sur la dentition de lait de Nycteris capensis (Chiropteres, Nycterides). Bull. Mus. Nat. Hist. Nat., Paris, ser. 2, vol. 24, no. 6, pp. 515–518. December, 1952.

DOZIER, HERBERT L. Muskrat production and management. Circular U. S. Fish & Wildlife Service, Washington, no. 18, pp. 42, illus. 1953.

EHIK, JULIUS. Ergänzende Angaben zur Kenntnis der Nordischen Wühlmaus, *Microtus ratticeps méhelyi* Ehik, 1928, in Ungarn. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 28–29. January 10, 1953.

EISENTRAUT, M. Beobachtungen über Jagdsoute und Flugbeginn bei Fledermäusen. Bonner Zool. Beiträge, Jahrgang 3, Heft 3–4, pp. 211–220. February 20, 1953.

EISENTRAUT, M. Contribution à l'étude biologique de *Paraechinus aethiopicus* Ehrenb. Mammalia, Paris, vol. 16, no. 4, pp. 232–252, illus. December, 1952.

ELTON, NORMAN W. Progress of sylvan yellow fever wave in Central America: Nicaragua and Honduras. Amer. Jour. Public Health, Albany, vol. 42, no. 12, pp. 1527–1534. December, 1952.

ENGLÄNDER, HANS. Beiträge zur Fortpflanzungsbiologie und Ontogenese der Fledermäuse. Bonner Zool. Beiträge, Jahrgang 3, Heft 3–4, pp. 221–230. February 20, 1953.

ERDBRINK, DIRK PIETER. A review of fossil and Recent bears of the Old World with remarks on their phylogency based upon their dentition. Drukkerij Jan de Lange, Deventer, pp. xii + 597, illus., 22 pls., 11 folding tables and maps. 1953. (Accompanied by "Index of cursivated names of animals and plants," pp. 1–12.)

ESCARIZ DE PEVERELLI, VICTORIA MARIA. Notas ecologicas acerca del "tuco-tuco". Ministerio de Agricultura y Ganaderia, Republica Argentina, Buenos Aires, año 8, no. 53, pp. 1–15, illus. 1952.

EVANS, FRANCIS C. Individuals and communities—a biologist's view. Michigan Alumnus Quarterly Review, vol. 58, no. 21, pp. 297–299. August 9, 1952.

FAILING, OTTO. The bobcat—hunter and hunted. Michigan Conservation, Lansing, vol. 22, no. 1, pp. 7–9, illus. January, 1953.

FELTEN, H. Beobachtungen an winterschlafender Fledermäusen im Rhein-Main-Gebiet. Säugertierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 8–13. January 10, 1953.

FELTEN, HEINZ. Untersuchungen zur Ökologie und Morphologie der Waldmaus (Apodemus sylvaticus L.) und der Gelbhalsmaus (Apodemus flavicollis Melchior) im Rhein-Main-Gebiet. Bonner Zool. Beiträge, Jahrg. 3, Heft 3–4, pp. 187–206. February 20, 1953.

FRANK, FRITZ. Kleine Beobachtungen an der Zwergmaus (Micromys minutus Pall.) mit ökologischen Folgerungen. Bonner Zool. Beiträge, Jahrg. 3, Heft 3–4, pp. 207–209. February 20, 1953.

FRANK, FRITZ. Zur Entstehung übernormaler Populationsdichten im Massenwechsel der Feldmaus, Microtus arvalis (Pallas). Zool. Jahrbücher, vol. 81, nos. 5–6, pp. 610–624. March 20, 1953.

FRECHKOP, SERGE. De la position systématique de la noctule. Mammalia, Paris, vol. 16, no. 4, pp. 216–222, illus. December, 1952.

GALBREATH, EDWIN C. A Contribution to the Tertiary geology and paleontology of northeastern Colorado. Univ. Kansas Paleont. Contrib. Vertebrata, art. 4, pp. 1–120,

pls. 2, figs. 26, March, 1953. (New: *Apternodus iliffensis, Ankylodon progressus, Domnina compressa, Pelycomys rugosus, P. placidus, Drassonax harpagops, Plesiosminthus? clivosus.*)

GREEN, E. L. A skeletal difference between sublines of the C3H strain of mice. Science, vol. 117, no. 3030, pp. 81–82. January 23, 1953.

GRZIMEK, BERNHARD. Beobachtungen an Schimpansen, *Pan troglodytes* (Blumenbach, 1775) in den Nimbabergen. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 1–5, illus. January 10, 1953.

GUIGUET, C. J. An ecological study of Goose Island, British Columbia, with special reference to mammals and birds. Occas. Papers British Columbia Provincial Mus., Victoria, no. 10, pp. 77, illus. March, 1953.

HAINARD, ROBERT. Notes sur le rut du bouquetin, *Capra i. ibex* Linné, 1758. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 26–28, illus. January 10, 1953.

HALL, E. RAYMOND, AND E. LENDELL COCKRUM. Comments on the taxonomy and distribution of North American microtines. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 5, no. 23, pp. 293–312. November 17, 1952.

HALL, E. RAYMOND, AND KEITH R. KELSON. Comments on the taxonomy and geographic distribution of some North American rodents. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 5, no. 26, pp. 343–371. December 15, 1952.

HALL, E. RAYMOND, AND E. LENDELL COCKRUM. A synopsis of the North American microtine rodents. Univ. Kansas Publ., Mus. Nat. Hist., Lawrence, vol. 5, no. 27, pp. 373–498, illus. January 15, 1953.

HANSTRÖM, B. The hypophysis in some South-African Insectivora, Carnivora, Hyracoidea, Proboscidea, Artiodactyla, and Primates. Arkiv för Zoologi, Stockholm, vol. 4, no. 3, pp. 187–294. January 21, 1953.

HARRIS, VAN T. Muskrats on tidal marshes of Dorchester County. Publ. Chesapeake Biol. Lab., Maryland Dept. Research & Education, Solomons Island, no. 91, pp. 36, 1952.

HARRISON, J. L. Insect-eating bats. Malayan Nature Jour., vol. 7, no. 5, pp. 191–195. March, 1953.

HATT, ROBERT T., ET AL. Faunal and archeological researches in Yucatan Caves. Bull. Cranbrook Inst. Sci., Bloomfield Mills, Michigan, no. 33, pp. 119, pls. 12. March, 1953. (Included articles: Introduction, by Robert T. Hatt; The mammals, by Robert T. Hatt; The birds, by Harvey I. Fisher; The reptiles and amphibians, by Dave A. Langebartel; Archeological findings, by George W. Brainerd.)

HAUGEN, ARNOLD O. Ammate in the diet of deer. Jour. Wildlife Management, Ithaca, vol. 17, no. 1, pp. 33–36. January, 1953.

HECK, HEINZ, JUN. Eine Nilpferdgeburt an Land. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 30–31. January 10, 1953.

HEINRICH, GERD. Zur Ökologie und Verbreitung der Brandmaus (Apodemus agrarius Pallas) Bonner Zool. Beiträge, Jahrg. 5, Heft 1–2, pp. 9–10. July 15, 1952.

HIBBARD, CLAUDE W. Equus (Asinus) colobatus Troxell and associated vertebrates from the Pleistocene of Kansas. Trans. Kans. Acad. Sci., vol. 56, no. 1, pp. 111–126, illus. March, 1953.

HIBBARD, CLAUDE W. Insectivores of the Rexroad fauna, Upper Pliocene of Kansas. Jour. Paleontol., vol. 27, no. 1, pp. 21–32. January, 1953. (New: *Sorex rexroadensis; Cryptotis? meadensis; Blarina adamsi*)

HILL, W. C. OSMAN. Observations on the genitalia of the woolly monkey (Lagothrix). Proc. Zool. Soc. London, vol. 122, pt. 4, pp. 973–984, illus. February, 1953.

HOOIJER, D. A. Pleistocene vertebrates from Celebes. V. Lower molars of Archidiskodon celebensis Hooijer. Zool. Mededel. Rijksmuseum Natuur. Hist., Leiden, vol. 31, no. 28, pp. 311–318, pl. 19. February 26, 1953.

HOOPER, EMMET T. Notes on mammals of Tamaulipas, Mexico. Occas. Papers Mus. Zool. Univ. Michigan, Ann Arbor, no. 544, pp. 12. March 25, 1953.

HOWARD, WALTER E., AND HENRY A. HJERSMAN. Deer repellent sprays not harmful to

foliage on two-year-old trees. Jour. Wildlife Management, Ithaca, vol. 16, no. 3, pp. 390–391. July, 1952.

HOWARD, WALTER E., AND KENNETH A. WAGNON. Guard those spuds—voracious squirrels show appetite for cull potatoes. Western Livestock Jour., vol. 29, no. 7, pp. 81–83. January, 1951.

HOWARD, WALTER E., AND LLOYD G. INGLES. Outline for an ecological life history of pocket gophers and other fossorial mammals. Ecology, vol. 32, no. 3, pp. 537–544. July, 1951.

JACKSON, WILLIAM B. Populations of the wood mouse (*Peromyscus leucopus*) subjected to the applications of DDT and Parathion. Ecological Monographs, vol. 22, pp. 259–281. October, 1952.

JAHN, GUNNAR, BIRGER BERGERSEN, AND EINAR VANGSTEIN. International whaling statistics. XXIX. Norske Hvalrads Statistiske Publ., Oslo, pp. 80. 1953.

JAHN, GUNNAR, BIRGER BERGERSEN, AND EINAR VANGSTEIN. International whaling statistics. XXX. Norske Hvalrads Statistiske Publ., Oslo, pp. 92. 1953.

JANSEN, JAN. Studies on the cetacean brain. The gross anatomy of the rhombencephalon of the fin whale (*Balaenoptera physalus* (L.)). Hvalrådets Skrifter, Sci. Results Marine Biol. Research, Oslo, no. 37, pp. 35, figs. 13. 1953.

JELLISON, WILLIAM L., CHARLES W. FISHEL, AND E. L. CHEATUM. Brucellosis in a moose, *Alces americanus*. Jour. Wildlife Management, Ithaca, vol. 17, no. 2, pp. 217–218. April, 1953.

JENKINS, D. H. Trappers and 'rats. Michigan Conservation, Lansing, vol. 22, no. 1, pp. 25–26. January, 1953. (Muskrat)

JOHNSON, DAVID H. (Review of) Mammals of Utah: taxonomy and distribution, by Stephen D. Durrant, and Mammals of Kansas, by E. Lendell Cockrum. Science, vol. 117, no. 3042, p. 428. April 17, 1953.

JORDAN, E. L. Hammond's nature atlas of America. C. S. Hammond & Co., New York, pp. 256, illus. 1952. (48 species of mammals, pp. 126–151, illustrated by Walter Ferguson)

KEELER, CLYDE E. Note on coat color and physiognomy in Norway rats. Jour. Tennessee Acad. Sci., vol. 28, no. 1, pp. 49–52. January, 1953.

KELLOGG, W. N., ROBERT KOHLER, AND H. N. MORRIS. Porpoise sounds as sonar signals. Science, Lancaster, vol. 117, no. 3036, pp. 239–243, illus. March 6, 1953.

KENYON, KARL W., AND VICTOR B. SCHEFFER. The seals, sea-lions, and sea otter of the Pacific coast. Wildlife Leaflet U. S. Fish & Wildlife Service, no. 344, pp. 28, illus. February, 1953.

KIRPICHNIKOV, A. A. O proiskhozdyenii chyernomorskogo dyelfina Phocaena phocaena relicta Abel. Zool Zhurnal, Moscow, vol. 31, no. 5, pp. 722–726. 1952.

KITTS, DAVID B. A Pleistocene musk-ox from New York and the distribution of the musk-oxen. Amer. Mus. Novitates, New York, no. 1607, pp. 1–8. January 2, 1953.

KOZLOV, V. I. Materialy k izucheniyu biologii enotovidnoi sobaki (Nyctereutes procyonoides Gray) v gorkovskoi oblasti. Zool. Zhurnal, Moscow, vol. 31, no. 5, pp. 761–768. 1952.

KRIEG, HANS. Tierpsychologische Beobachtungen in Südamerika. Veröffent. Zool. Staatssammlung München, vol. 1, pp. 63–96. January 1, 1950.

KUBIK, JERZY. Biologische und morphologische Untersuchungen über die Birkenmaus im Naturschutzpark von Bialowieza. Ann. Univ. Mariae Curie-Sklodowska, vol. 7, no. 1, pp. 1–63. June 25, 1952. (*Sicista betulina*)

KURODA, N. On a specimen of rare Rattus tanezumi obtained in Aomori Prefecture. Annot. Zool. Japonenses, vol. 24, no. 4, pp. 234–237. December, 1951.

LADYGENA, N. M. Sezonnye ezmeneniya reaktsii domovykh myshey—Mus musculus L. na vozdeystvie temperatury. Zool. Zhurnal, Moscow, vol. 31, no. 5, pp. 736–743. 1952.

LIU, T. T. The measurement of fertility and its use as an index of reproductive isolation

among certain laboratory stocks of Peromyscus. Contrib. Lab. Vert. Biol. Univ. Michigan, Ann Arbor, no. 59, pp. 1–12. February, 1953.

LIU, T. T. Prenatal mortality in Peromyscus with special reference to its bearing on reduced fertility in some interspecific and intersubspecific crosses. Contrib. Lab. Vert. Biol. Univ. Michigan, Ann Arbor, no. 60, pp. 1–32, illus. February, 1953.

LYNE, A. G. Notes on external characters of the pouch young of four species of bandicoots. Proc. Zool. Soc. London, vol. 122, pt. 3, pp. 625–649, illus., pls. 2. November, 1952.

MADISON, CAROLINE R. A search for quantitative differences in the normal constituents of the urine of short ear and normal mice. Jour. Exper. Zool., vol. 120, no. 3, pp. 457–468. August, 1952.

MALTHANER, HUBERT. Der Komparabilwert des Gehirnes und die Methoden zur Bestimmung der Ranghöhe von Wirbeltieren. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 5–8. January 10, 1953.

MANN, F., GUILLERMO. Esquema ecologico de selva, sabana y cordillera en Bolivia. Publ. Inst. Geografía, Facultad de Filosofía, Universidad de Chile, Santiago, no. 3, pp. 236, illus. 1951.

MATHESON, COLIN. Some aspects of urban zoology in Great Britain. Sci. Monthly, Lancaster, vol. 76, no. 1, pp. 29–32. January, 1953.

MATHIAK, HAROLD A. Experimental level ditching for muskrat management. Tech. Wildlife Bull. Wisconsin Conserv. Dept., Madison, no. 5, pp. 35, illus. 1953.

MAYER, WILLIAM V. Preliminary growth studies of the Barrow ground squirrel, Citellus parryi barrowensis. Anatomical Record, Philadelphia, vol. 113, no. 4, pp. 585–586. August, 1952. (Abstract)

MCMILLAN, JOHN F. Some feeding habits of moose in Yellowstone Park. Ecology, Lancaster, vol. 34, no. 1, pp. 102–110. January, 1953.

MEESTER, J. A new golden mole from Spitzkop, Sabie. South African Jour. Sci., vol. 49, no. 6, pp. 207–208. January, 1953. (New: *Bematiscus villosus rufus*)

MIRONOV, N. P., A. N. PAVLOV, F. A. PUSHNITSA, AND P. I. SHIRANOVICH. Izmenenie granitsky areala malogo suslika v donskikh: starropolskikh stepyakh. Zool. Zhurnal, Moscow, vol. 31, no. 5, pp. 752–760. 1952. (*Citellus pygmaeus*)

MOHR, ERNA. Die "letzten" Wölfe von Niedersachsen. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 22–26, illus. January 10, 1953.

MOORE, JOSEPH CURTIS. Distribution of marine mammals to Florida waters. Amer. Midland Nat., Notre Dame, vol. 49, no. 1, pp. 117–158. January, 1953.

MORRISON, PETER R., AND WILLIAM J. TEITZ. Observations on food consumption and preference in four Alaskan mammals. Arctic, Jour. Arctic Inst. North America, Ottawa, vol. 6, no. 1, pp. 52–57. March, 1953. (*Citellus*, *Clethrionomys*, *Dicrostonyx*, *Ochotona*).

MÜLLER-USING, D. Über den Zehenspitzengang des Feldhasen, *Lepus europaeus* Pallas, 1778. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, p. 21. January 10, 1953.

MUMFORD, RUSSELL E. Bat banding in Indiana caves. Outdoor Indiana, vol. 20, no. 1, pp. 7–10, illus. January, 1953.

NASH, JOHN BLAKE. An investigation of some problems of ecology of the beaver in northern Manitoba. Dept. Mines and Natural Resources, Game and Fisheries Branch, Manitoba, pp. 64, multilithed. April, 1951.

NOUVEL, J. La reproduction des mammifères au parc zoologique du Bois de Vincennes dans ses rapports avec l'alimentation. Mammalia, Paris, vol. 16, no. 3, pp. 160–175. September, 1952.

OELRICH, THOMAS M. A new Testudo from the Upper Pliocene of Kansas with additional notes on associated Rexroad mammals. Trans. Kansas Acad. Sci., Topeka, vol. 55, no. 3, pp. 300–311, illus. 1952.

OLIVIER, GEORGES. Le sacrum du semnopithèque. Mammalia, Paris, vol. 16, no. 3, pp. 122–136, illus. September, 1952.

PAPP, A., AND E. THENIUS. Über die Grundlagen der Gleiderung des Jungtertiärs und Quartärs in Niederosterreich unter besonderer Berücksichtigung der Mio-Pliozän-und Tertiar-Quartär-Grenze. Sitz.-Ber. Osterr. Akad. Wiss., Vienna math.-naturw. Kl., vol. 158, pp. 763–787, illus. 1949.

PAULIAN, PATRICE. Sur la présence aux îles Kerguelen d'*Hydrurga leptonyx* (Bl.) et d'*Arctocephalus gazella* (Pet.) et notes biologiques sur deux phocidés. Mammalia, Paris, vol. 16, no. 4, pp. 223–227. December, 1952.

PEARSON, PAUL G. A note on the food habits of captive shrews, *Cryptotis floridana*. Quarterly Jour. Florida Acad. Sci., vol. 14, no. 1, pp. 49–50. March, 1951.

PEARSON, PAUL G. A field study of Peromyscus populations in Gulf Hammock, Florida. Ecology, vol. 34, no. 1, pp. 199–207, illus. January, 1953.

PEDERSEN, TORBJØRN. A note on humpback oil and on the milk and milk fat from this species (Megaptera nodosa). Norsk Hvalfangst-Tidende (Norwegian Whaling Gazette), Sandefjord, vol. 41, no. 7, pp. 375–378. July, 1952.

PERRY, J. S. The reproduction of the African elephant, Loxodonta africana. Philos. Trans. Royal Soc. London, ser. B, vol. 237, pp. 93–149. February 10, 1953.

PETITT, ROBERT M. Vertebrate remains in barn owl pellets from Stanton County, Kansas. Trans. Kansas Acad. Sci., Topeka, vol. 54, no. 3, p. 395. 1951.

PETRIDES, GEORGE A. Aerial deer counts. Jour. Wildlife Management, Ithaca, vol. 17, no. 1, pp. 97–98. January, 1953.

PETTER, F. Note préliminaire sur l'éthologie et l'écologie de *Psammomys obesus* Cretzschmar. Mammalia, Paris, vol. 16, no. 3, pp. 137–147, illus. September, 1952.

PIRLOT, P. L. The preorbital fossa of Hipparion. Amer. Jour. Sci., New Haven, vol. 251, no. 4, pp. 309–312. April, 1953.

RAND, R. W. The Government guano islands: birds and seals. Union of South Africa Dept. Agric., Pretoria, pp. 15, illus. 1950.

REEDER, WILLIAM G. The deciduous dentition of the fish-eating bat, *Pizonyx vivesi*. Occas. Papers Mus. Zool. Univ. Michigan, Ann Arbor, no. 545, pp. 3, pl. 1. March 25, 1953.

REYNOLDS, HAROLD C. Studies on reproduction in the opossum (Didelphis virginiana virginiana). Univ. California Publ. Zool., vol. 52, no. 3, pp. 223–284, illus. November 13, 1952.

RODBARD, SIMON. Weight and body temperature in mammals. Science, Lancaster, vol. 117, no. 3036, pp. 256–257. March 6, 1953.

ROKITANSKY, GERTH. Gefangenschaftsbeobachtungen an der Streifenmaus (Sicista subtilis Pallas). Bonner Zool. Beiträge, Jahrg. 3, Heft 1–2, pp. 1–9. July 15, 1952.

ROKITANSKY, GERTH. Höchstlebensalter der Gelbhalsmaus, *Apodemus flavicollis* Melchior, 1834. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 29–30. January 10, 1953.

RUSSELL, ROBERT J. Description of a new armadillo (Dasypus novemcinctus) from Mexico with remarks on geographic variation of the species. Proc. Biol. Soc. Washington, vol. 66, pp. 21–26. March 30, 1953. (New: *Dasypus novemcinctus davisi*)

SANBORN, COLIN CAMPBELL. Rodents (*Muridae*) from Lunda District, northeastern Angola. Publicações Culturais da Companhia de Diamantes de Angola, Lisbon, no. 14, pp. 107–120, map. August 5, 1952.

SANBORN, COLIN CAMPBELL. Remarks on a Japanese bat, Vespertilio macrodactylus Temminck. Nat. Hist. Misc., Chicago Acad. Sci., no. 118, pp. 1–3. March 13, 1953.

SANDERSON, GLEN C. Methods of measuring productivity in raccoons. Jour. Wildlife Management, vol. 14, no. 4, pp. 389–402. October, 1950.

SAPIN-JALOUSTRE, J. Les phoques de Terre Adélie. Mammalia, Paris, vol. 16, no. 4, pp. 179–212, illus. December, 1952.

SCHMIDT-NIELSEN, BODIL, KNUT SCHMIDT-NIELSEN, ADELAIDE BROKAW, AND HOWARD SCHNEIDERMAN. Water conservation in desert rodents. Jour. Cellular & Comp. Physiol., vol. 32, no. 3, pp. 331–360. December, 1948.

SCHMIDT-NIELSEN, BODIL, AND KNUT SCHMIDT-NIELSEN. Do kangaroo rats thrive when drinking sea water? Amer. Jour. Physiol., vol. 160, no. 2, pp. 291–294. February, 1950.

SCHMIDT-NIELSEN, BODIL, AND KNUT SCHMIDT-NIELSEN. Pulmonary water loss in desert rodents. Amer. Jour. Physiol., vol. 162, no. 1, pp. 31–36. July, 1950.

SCHMIDT-NIELSEN, KNUT, BODIL SCHMIDT-NIELSEN, AND ADELAIDE BROKAW. Urea excretion in desert rodents exposed to high protein diets. Jour. Cellular & Comp. Physiol., vol. 32, no. 3, pp. 361–379. December, 1948.

SCHWARTZ, ALBERT. A new race of the round-tailed muskrat, *Neofiber alleni*, from southern Florida. Nat. Hist. Misc., Chicago Acad. Sci., no. 101, pp. 1–3. February 15, 1952. (New: *Neofiber alleni struix*.)

SEALANDER, JOHN A., JR. Body temperatures of white-footed mice in relation to environmental temperature and heat and cold stress. Biological Bull., Lancaster, vol. 104, no. 1, pp. 87–99. February, 1953.

SNIGIREVSKAYA, E. M. Royushchaya deyatelnost i ubezhisheha zheltogorloy myshi. Zool. Zhurnal, Moscow, vol. 31, no. 5, pp. 744–751. 1952. (Yellow-throated mouse)

SPERLING, FREDERICK. Organ: body weight, protein: organ and fat: organ ratios in large albino rats. Growth, vol. 17, no. 1, pp. 1–6. March, 1953.

SPRINZ, R. The innervation of the trunk of the Indian elephant. Proc. Zool. Soc. London, vol. 122, pt. 3, pp. 621–623, illus. November, 1952.

STEIN, GEORG H. W. Über Umweltabhängigheiten bei der Vermehrung der Feldmaus, *Microtus arvalis*. Populationsanalytische Untersuchungen an deutschen kleinen Säugetieren IV. Zool. Jahrbücher, vol. 81, nos. 5–6, pp. 527–547. March 20, 1953.

STIRTON, R. A. Are Petaluma horse teeth reliable in correlation? Bull. Amer. Assoc. Petrol. Geol., vol. 36, no. 10, pp. 2011–2025, illus. October, 1952.

TABER, RICHARD D. The secondary sex ratio in *Odocoileus*. Jour. Wildlife Management, Ithaca, vol. 17, no. 1, pp. 95–97. January, 1953.

TAKASHIMA, H. The romance of Père David's deer. Misc. Repts. Yamashina's Inst. Ornithol. & Zool., Tokyo, no. 1, pp. 5–14, illus. December, 1952. (In Japanese, with English summary)

TANAKA, RYÔ. Theoretical justification of the mark-and-release index for small mammals. Bull. Kochi Women's College, Shikoku, Japan, vol. 1, pp. 38–47, illus. December, 1952.

TANAKA, RYÔ. Further study on vole and mouse populations on Mt. Ishizuchi. Annot. Zool. Japonenses, vol. 25, nos. 1–2, pp. 279–283. January, 1952.

THENIUS, ERICH. Fischotter und Bisamspitzmaus aus dem Altquartär von Hundsheim in Niederosterreich. Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 157, pp. 187–202, illus. 1948. (New: *Desmana thermalis hundsheimensis*)

THENIUS, ERICH. Über die Entwicklung des Hornzapfens von *Miotragocerus*. Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 157, pp. 203–221, 1948.

THENIUS, ERICH. Über die Gehörregion von *Indarctos* (*Ursidae*, Mamm.). Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 158, pp. 647–653, 1949.

THENIUS, ERICH. Über die Säugetierfauna aus dem Unterpliozän von Ilhan bei Ankara (Türkei). Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 158, pp. 656–661. 1949.

THENIUS, ERICH. Die Carnivoren von Göriach (Steiermark). Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 158, pp. 695–762, illus. 1949.

THENIUS, ERICH. *Martes gamlitzensis* H. v. Meyer. Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 158, pp. 793–797. 1949.

THENIUS, ERICH. Zur Herkunft der Simocyoniden (Canidae, Mammalia). Sitz.-Ber. Österr. Akad. Wiss., Vienna, math.-naturw. Kl., vol. 158, pp. 799–810. 1949.

THENIUS, ERICH. Zur Analyse des Gebisses des Eisbären, *Ursus* (*Thalarctos*) *maritimus* Phippe, 1774. Säugetierk. Mitteil., Stuttgart, vol. 1, no. 1, pp. 14–20, illus. January 10, 1953.

THOMPSON, HARRY V. The edible dormouse (Glis glis L.) in England, 1902–1951. Proc. Zool. Soc. London, vol. 122, pt. 4, pp. 1017–1024, pls. 2, February, 1953.

TORRE, LUIS DE LA. An additional record of the bat, *Sturnira ludovici*, in Mexico. Nat. Hist. Misc., Chicago Acad. Sci., no. 105, pp. 2. May 2, 1952.

TYNDALE-BISCOE, C. H. A method of marking rabbits for field studies. Jour. Wildlife Management, Ithaca, vol. 17, no. 1, pp. 42–45. January, 1953.

VAN GELDER, RICHARD G., AND DONALD F. HOFFMEISTER. Canine teeth in white-tailed deer. Jour. Wildlife Management, Ithaca, vol. 17, no. 1, p. 100, illus. January, 1953.

VENDELOO, N. H. VAN. On the correlation between the masticatory muscles and the skull structure in the muskrat, Ondatra zibethica (L.). I. Proc. Kon. Nederlandse Akad. Wetenschappen, vol. 56, no. 1, pp. 116–127. 1953.

VETULYANI, TADEUSH. Problema tarpana nafone noveyshekh rabot Akademii Nauk SSSR po istorii loshadey v starom svete. Zool. Zhurnal, Moscow, vol. 31, no. 5, pp. 727–735. 1952. (Tarpan)

VIETINGHOFF-RIESCH, ARNOLD FRHR. v. Beiträge zur Biologie des Siebenschläfers (Glis glis L.). Bonner Zool. Beiträge, Jahrg. 3, Heft 3–4, pp. 167–186. February 20, 1953.

VOIPIO, PAAVO. Subspecific boundaries and genodynamics of populations in mammals and birds. Ann. Zool., Soc. Zool. Bot. Fennica "Vanamo", vol. 15, no. 4, pp. 1–32. 1952.

WILLAN, R. L., C. A. M. SMITH, AND P. SMITH. Atlantic seals on a Welsh breeding island: studies of seal cows & calves. . . . Illus. London News, vol. 222, no. 5935, pp. 90–91, illus. January 17, 1953.

WILLAN, R. L. Wild African elephants drinking and bathing. Illus. London News, vol. 222, no. 5942, p. 367, illus. March 7, 1953.

WRIGHT, BRUCE S. Further notes on the panther in the northeast. Canadian Field-Nat., vol. 67, no. 1, pp. 12–28. January–March, 1953.

ZUCKERMAN, S. The breeding seasons of mammals in captivity. Proc. Zool. Soc. London, vol. 122, pt. 4, pp. 827–950, illus. February, 1953.

COMMENTS AND NEWS

HONORARIA FOR GRADUATE STUDENTS

In order to encourage young mammalogists and to stimulate research, The American Society of Mammalogists awards Honoraria of fifty dollars ($50.00) each to young graduate students for the purpose of attending, and presenting a paper at, the annual meeting. Four such grants may be awarded each year for papers to be presented at the annual meeting.

Papers submitted for such awards for 1954 must be in the hands of the Committee on Honoraria for Graduate Students by April 1, 1954. Send manuscripts to the chairman of the committee, W. Robert Eadie, Fernow Hall, Cornell University, Ithaca, New York. For further details concerning the awards consult Journal of Mammalogy, Vol. 32, page 387.

The annual meeting in 1954 is tentatively scheduled for June in Rocky Mountain National Park in Colorado.

SOCIETY FOR MAMMALOGICAL RESEARCH FOR BELGIUM, THE NETHERLANDS, AND LUXEMBURG

In addition to the note in Vol. 33, No. 4 in this Journal, it is reported that Dr. A. de Vos, Dept. of Entomology and Zoology, Ontario Agricultural College, will be in regular contact with the Secretary of this Society, Dr. A. Scheygrond, and that the former will be glad to provide information regarding the new Society.

The Society issues an information bulletin in which are contained references to recent literature on mammalogy in the Benelux countries. The Board of the Society also recently made an arrangement with the editors of "Mammalia" to reserve a special section of this Journal for scientific publications.

CORRECTION

Changes from the original manuscript in my recent article on the antelope ground squirrel (Jour. Mamm., 34) should be made as follows: page 329, line four should read "igneous and metamorphic rocks"; and on page 331, line 32 should read "the ground uta (*Uta stansburiana*)" instead of "the blue-bellied swift (*Sceloporus occidentalis*)".—Albert C. Hawbecker.

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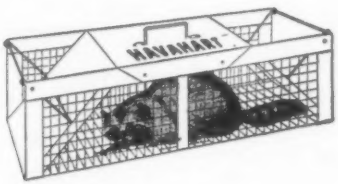

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